UNCLASSIFIED

AD NUMBER
AD872475
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; AUG 1970. Other requests shall be referred to Arnold Engineer Development Center, Arnold AFB, TN.**
AUTHORITY
AEDC ltr 10 Apr 1975

THIS PAGE IS UNCLASSIFIED

AEDC-TR-70-163

Copy 1

SUPPLEMENTAL CALIBRATION RESULTS FOR THE AEDC PROPULSION WIND TUNNEL (16T)

F. M. Jackson

ARO, Inc.

August 1970

This document has been approved for public release its distribution is unlimited. Per AF Letter dt'd 10 Jul, 75 signed William O. Cole.

~~This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of Arnold Engineering Development Center (AETS), Arnold Air Force Station, Tennessee 37389.~~

PROPULSION WIND TUNNEL FACILITY
ARNOLD ENGINEERING DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND
ARNOLD AIR FORCE STATION, TENNESSEE

NOTICES

AEDC-TR-70-163

SUPPLEMENTAL CALIBRATION RESULTS FOR THE AEDC PROPULSION WIND TUNNEL (16T)

F. M. Jackson

ARO, Inc.

FOREWORD

The work reported herein was done at the request of the Aeronautical Systems Division (ASD) and Air Force Flight Dynamics Laboratory (AFFDL) in support of the C-5A correlation test which was completed in January 1970 under Program Element 62201F.

The test results were obtained by ARO, Inc. (a subsidiary of Sverdrup & Parcel and Associates, Inc.), contract operator of the Arnold Engineering Development Center (AEDC), under Contract F40600-71-C-0002. This supplemental test, which was requested by ASD, was conducted on December 30 and 31, 1969, under ARO Project No. PB0068, and the manuscript was submitted for publication on May 13, 1970.

Information in this ~~report~~ is embargoed under the ~~Department~~ of State ~~International~~ Traffic in Arms Regulations. This ~~report~~ may be released ~~to~~ foreign governments by departments or agencies of the U. ~~S.~~ Government subject to approval of the Arnold Engineering Development Center (AETS), or higher authority within the Department of the Air Force. Private individuals or firms require a Department of State export license.

This technical report has been reviewed and is approved.

George F. Garey
Lt Colonel, USAF
AF Representative, PWT
Directorate of Test

Roy R. Croy, Jr.
Colonel, USAF
Director of Test

This document has been approved for public release its distribution is unlimited. Per AF Letter Dtd 10 April 75 signed William O. Cole

ABSTRACT

Tests were conducted in the AEDC Propulsion Wind Tunnel (16T) to determine the centerline Mach number distributions and the corresponding tunnel calibration parameters. The tests were conducted over the Mach number range from 0.20 to 1.00. A quantitative evaluation of the effects of Mach number, tunnel pressure ratio, test section wall angle, and diffuser flap position upon the centerline Mach number distributions was determined by analysis of the local Mach number deviations and the longitudinal Mach number gradients. The results indicate that the centerline Mach number distributions are better than the wall distributions obtained during a previous calibration. For most operating conditions, the difference between the present centerline calibration and the previous calibration is considered negligible.

CONTENTS

APPENDIXES

I. ILLUSTRATIONS

NOMENCLATURE

f_D	Diffuser flap position, in. (positive when flaps are diverged)
G	Centerline Mach number gradient, $\Delta M/ft$
M	Nominal Mach number for a selected set of data
M_c	Equivalent plenum Mach number
M_∞	Free-stream Mach number; determined from the average of local Mach numbers from Tunnel Station 3.0 to 19.0
θ_w	Test section wall angle, deg (positive when walls are diverged)
λ	Tunnel pressure ratio, ratio of the stilling chamber pressure to the compressor inlet pressure
$\lambda*$	Optimum tunnel pressure ratio

σ	Standard deviation
ω	Auxiliary flow requirements in percent of tunnel weight flow

SECTION I
INTRODUCTION

During the development of the Lockheed C-5A aircraft, wind tunnel tests were conducted in several test facilities. Among these were the Ames Research Center 11-ft, the Cornell Aeronautical Laboratory 8-ft, and the Arnold Engineering Development Center (AEDC) 16-ft transonic tunnels. Comparison of data from these facilities revealed significant differences, especially in the measured drag coefficient.

These results prompted a correlation investigation in the aforementioned wind tunnels involving a 0.0226-scale model of the C-5A aircraft. The initial series of tests indicated that among several factors which affect the correlation of data are the Mach number gradient and Mach number measurement in the test facilities.

The most recent calibration of the AEDC Propulsion Wind Tunnel (16T) is reported in Ref. 1. The Ref. 1 calibration was based on test section wall static pressure measurements. To support the second phase of the C-5A correlation test, an investigation was conducted in Tunnel 16T to determine the centerline Mach number distributions and the corresponding tunnel calibration parameters. The results of this investigation are presented in this report.

SECTION II
APPARATUS

2.1 TEST FACILITY

Tunnel 16T is a continuous flow, closed-circuit tunnel which can be operated at Mach numbers from 0.20 to 1.60. It is a variable density tunnel which has a test section 40 ft long and 16 ft square with 6-percent porosity walls. The test section sidewalls can be either converged or diverged. The general arrangement of the test section and the perforated wall geometry is shown in Fig. 1 (Appendix I). A detailed description of the tunnel and its capabilities is given in Ref. 2.

2.2 INSTRUMENTATION

A 2.875-in.-diam static pressure pipe was used to obtain the centerline static pressure distribution from tunnel station 2.0 to 23.5. The

rear end of the pipe was attached to the Tunnel 16T sting support system. The pipe was subject to a tensile load through the use of four cables at the forward end. A schematic of the installation, including the orifice spacing, is given in Fig. 1. A photograph of the installation is shown in Fig. 2.

Selected pipe orifices and several wall orifices in the tunnel nozzle and test section were connected to differential pressure transducers. The transducers were referenced to a fixed pressure which was approximately equal to the plenum chamber pressure at each test condition. The tunnel stagnation pressure was determined by averaging measurements from two self-balancing precision manometers. The tunnel plenum chamber pressure was determined by averaging measurements from four differential pressure transducers which were also referenced to the trapped reference pressure.

SECTION III
PROCEDURE

3.1 GENERAL

The calibration was conducted over the Mach number range from 0.2 to 1.0. Particular emphasis was placed upon investigation at the specific Mach numbers at which the C-5A correlation test was to be conducted. Sufficient data were obtained at $M_\infty > 1.0$ to conclude that the pipe installation used for this test was unsatisfactory for calibration at supersonic Mach numbers.

For $M_\infty \geq 0.6$, the stagnation temperature was maintained at 100°F and the stagnation pressure was set to obtain a unit Reynolds number of 3.0×10^6/ft. For $M_\infty < 0.6$, the stagnation temperature and pressure were held at about 75°F and 1000 psfa, respectively.

3.2 TEST DISCUSSION

In addition to Mach number, the variables of interest were tunnel pressure ratio (λ), test section wall angle (θ_w), and diffuser flap position (f_D).

The tunnel pressure ratio was varied from 1.080 to 1.174 at $\theta_w = 0$ and $f_D = 0$. Based on the centerline Mach number distributions and the tunnel power requirements, an optimum pressure ratio schedule, $\lambda*$, was defined. This schedule is illustrated in Fig. 3a.

The test section wall angle was varied from -0.25 to 0.50 at $\lambda = \lambda*$ and $f_D = 0$. Wall divergence from the tunnel centerline is considered positive.

The diffuser flap position was varied from 0 to 18 in. at $\theta_w = 0$. Plenum suction with the auxiliary compressor system was not utilized with diffuser flap variation; therefore, the pressure ratio was varied to establish Mach number.

The minimum Mach number available in Tunnel 16T with normal operating procedure is $M_\infty = 0.55$. Lower Mach numbers are obtained by operating the compressor drive system subsynchronously. The compressor operating characteristics for this mode of operation at a stagnation temperature of 75°F are illustrated in Fig. 3b.

3.3 DATA REDUCTION AND PRECISION

The distribution of local static pressure in the test section was obtained from measurements with a centerline pipe. The instrumentation setup is discussed in Section 2.2. The pressure data were reduced to Mach number assuming isentropic flow through the nozzle.

The average Mach number, the 2σ Mach number deviation, and the longitudinal Mach number gradient, G, were computed for two test section regions. These include Tunnel Station 7.83 to 13.17, the region in which the C-5A model will be installed, and Tunnel Station 3.0 to 19.0, the region for which the tunnel calibration parameters are defined.

The statistical parameter, σ, the standard deviation, is approximately a root-mean-square quantity which is a measure of the deviation of the local Mach numbers from the average. Assuming a normal distribution, 95.4 percent of the local Mach number will fall within a distribution band of $\pm 2\sigma$.

The centerline Mach number gradient, G, was obtained by utilizing the method of least squares to determine the straight line of best fit for each of the distributions.

The uncertainties in the data which can be attributed to instrumentation errors and data acquisition techniques are presented below. The uncertainties were determined for a confidence level of 95.4 percent.

Δf_D	±0.25
ΔM_c	±0.0011
ΔM_∞	±0.0003
$\Delta \theta_w$	±0.05
$\Delta \lambda$	±0.001

SECTION IV
DISCUSSION OF RESULTS

4.1 CENTERLINE MACH NUMBER DISTRIBUTIONS

4.1.1 General

Tunnel 16T centerline Mach number distributions were obtained at a variety of test conditions. Typical distributions which were obtained at Mach numbers from 0.202 to 1.000 are presented in Fig. 4. The acceleration of the flow at the forward portion of the test section was atttributed to interference from the cables which were attached to the pipe. The deceleration of the flow at the rear of the distributions was attributed to the effects of the pipe support system interference.

4.1.2 Effects of Mach Number

The centerline Mach number distributions for various Mach numbers at $\theta_w = 0$, $f_D = 0$, and $\lambda = \lambda^*$ are presented in Fig. 4. The effect of Mach number upon the Mach number deviations and gradients is illustrated in Figs. 5 and 6, respectively. The data for Tunnel Station 3.0 to 19.0 at $M_\infty > 0.9$ are not presented because the adverse effect of the pipe cable supports was considered significant.

The data in Fig. 5b indicate that the deviations for Tunnel Station 3.0 to 19.0 varied from 0.0009 at $M_\infty = 0.20$ to 0.0024 at $M_\infty = 0.90$. A comparison of these data with those in Ref. 1 indicates that the centerline Mach number deviations were lower than those obtained in Ref. 1 from wall distributions.

Although the Mach number deviations and gradients were sensitive to the choice of test region, they are indicative of the quality of a Mach number distribution. Since the deviations reported here and those in Ref. 1 were defined in a similar manner, the data in Fig. 5b indicate that the centerline Mach number distributions were better than the distributions obtained in Ref. 1.

The data in Fig. 6a illustrate that for Tunnel Station 7.83 to 13.17, the gradients were less than ±0.0001 for $M_\infty < 0.60$ but varied from -0.0001 at $M_\infty = 0.60$ to -0.0007 at $M_\infty = 1.0$. A buoyancy correction to wind tunnel axial-force data can be made to cancel the effects of longitudinal gradients. The procedures for obtaining buoyancy corrections and the corrections for a typical test in Tunnel 16T are presented in Appendix II.

4.1.3 Effects of Tunnel Pressure Ratio

The effects of tunnel pressure ratio variation upon the centerline Mach number distributions were investigated at M = 0.700, 0.767, 0.825, 0.900, and 1.000. The centerline Mach number distributions which were obtained are illustrated in Fig. 7. These data indicate that the Mach number distributions and the auxiliary flow requirements, ω, did not change significantly as the pressure ratios were increased beyond certain values. This result was utilized to define the optimum pressure ratio schedule which is shown in Fig. 3a. Operation at pressure ratios above the optimum will only increase the tunnel power requirements.

The Mach number deviations and gradients are illustrated in Figs. 8 and 9, respectively. In general, the deviations and gradients increased as the pressure ratio was decreased below the optimum pressure ratio, λ^*. For pressure ratio variation from 8 percent below the optimum to the maximum, the deviations and gradients varied by less than ±0.0003 and ±0.0001, respectively. These data indicate that the Mach number distributions were not significantly affected by pressure ratio variation within the normal operating range.

4.1.4 Effects of Wall Angle

The test section wall angle was varied from 0.50 to -0.25 deg at M = 0.600, 0.700, 0.767, 0.825, 0.900, and 1.000. The centerline Mach number distributions which were obtained are illustrated in Fig. 10. For M = 0.60 and 0.70, where no auxiliary suction was used, $\omega = 0$, wall divergence reduced the pressure ratio requirements and hence the tunnel power requirements. For M > 0.70 and optimum pressure ratios, the auxiliary flow requirements were a minimum at $\theta_W = 0.25$.

The effects of wall angle variation upon the Mach number deviations and gradients are presented in Figs. 11 and 12. These data illustrate that, in general, the deviations and gradients decreased with wall divergence. These data indicate that wall divergence to either $\theta_w = 0.25$ or 0.50 improved the Mach number distributions.

4.1.5 Effects of Diffuser Flaps

The effects of diffuser flap variation upon the centerline Mach number distributions were investigated at M = 0.600, 0.702, 0.800, and 0.899 for zero auxiliary suction, $\omega = 0$. The centerline Mach number distributions are shown in Fig. 13. The maximum Mach number which was obtained without auxiliary suction was $M_\infty = 0.932$ at $f_D = 18.0$.

The Mach number deviations and gradients are illustrated in Figs. 14 and 15. The effect of diffuser flap variation upon the deviations and the gradients and therefore the centerline Mach distributions was not significant.

4.2 CALIBRATION PARAMETERS

The Tunnel 16T centerline Mach number calibration for various wall angles at $f_D = 0$ and $\lambda = \lambda^*$ is shown in Fig. 16. The scatter in these data was attributed to the different response of the various instrumentation systems to fluctuations of tunnel pressures.

The Ref. 1 calibration is presently utilized to establish test conditions in Tunnel 16T. A comparison of the results of this test with data from Ref. 1 indicates that for $\theta_w = 0.25$, 0.50, and most conditions at $\theta_w = 0$, the Mach numbers from this calibration and the Ref. 1 calibration agreed within ±0.001. This disagreement is considered negligible.

SECTION V
CONCLUSIONS

Based on the results from this centerline calibration of Tunnel 16T, the following conclusions are made:

1. The subsonic Mach number distributions, obtained during this centerline calibration, were better than the Ref. 1 wall distributions.

2. Test section wall divergence to either $\theta_w = 0.25$ or 0.50 improved the Mach number distributions.
3. The Mach number distributions were not significantly affected by pressure ratio variation within the normal operating range.
4. The effect of diffuser flap variation upon the centerline Mach number distributions was not significant.
5. At $\theta_w = 0.25$, 0.50, and most conditions at $\theta_w = 0$, the difference between this calibration and the Ref. 1 calibration was considered negligible.
6. The centerline pipe installation used for this test was unsatisfactory for calibration at supersonic Mach numbers.

REFERENCES

1. Gunn, J. A. "Check Calibration of the AEDC 16-Ft Transonic Tunnel." AEDC-TR-66-80 (AD633277), May 1966.
2. Test Facilities Handbook (Eighth Edition). "Propulsion Wind Tunnel Facility, Vol. 5." Arnold Air Force Station, Tennessee, Arnold Engineering Development Center, December 1969 (AD863646).
3. Pope, Alan. "Wind Tunnel Boundary Corrections," Wind Tunnel Testing. (Second Edition) John Wiley and Sons, Inc., November 1958.

APPENDIXES
I. ILLUSTRATIONS
II. BUOYANCY CORRECTION

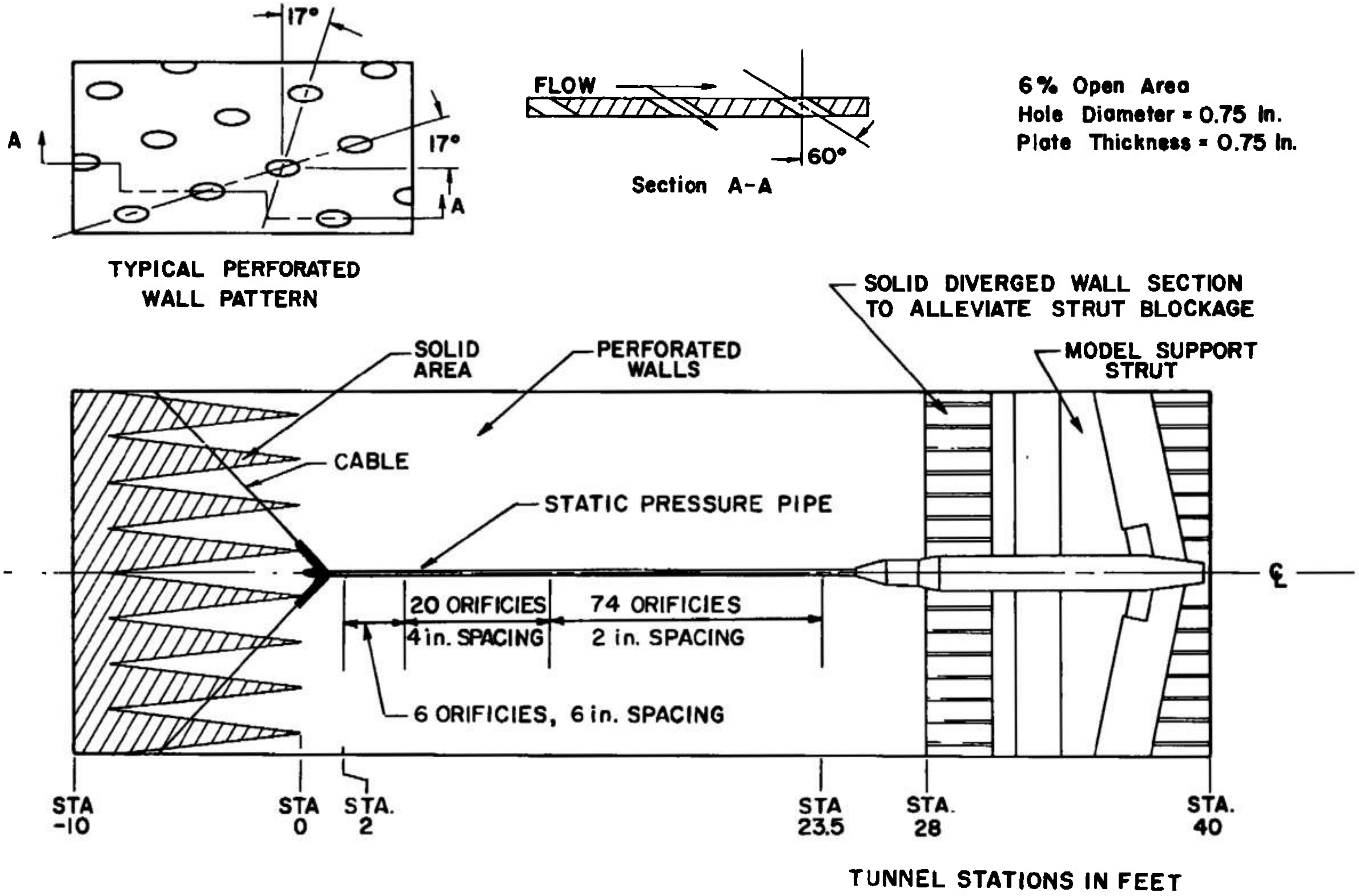


Fig. 1 Schematic of the Test Section and Centerline Pipe Installation

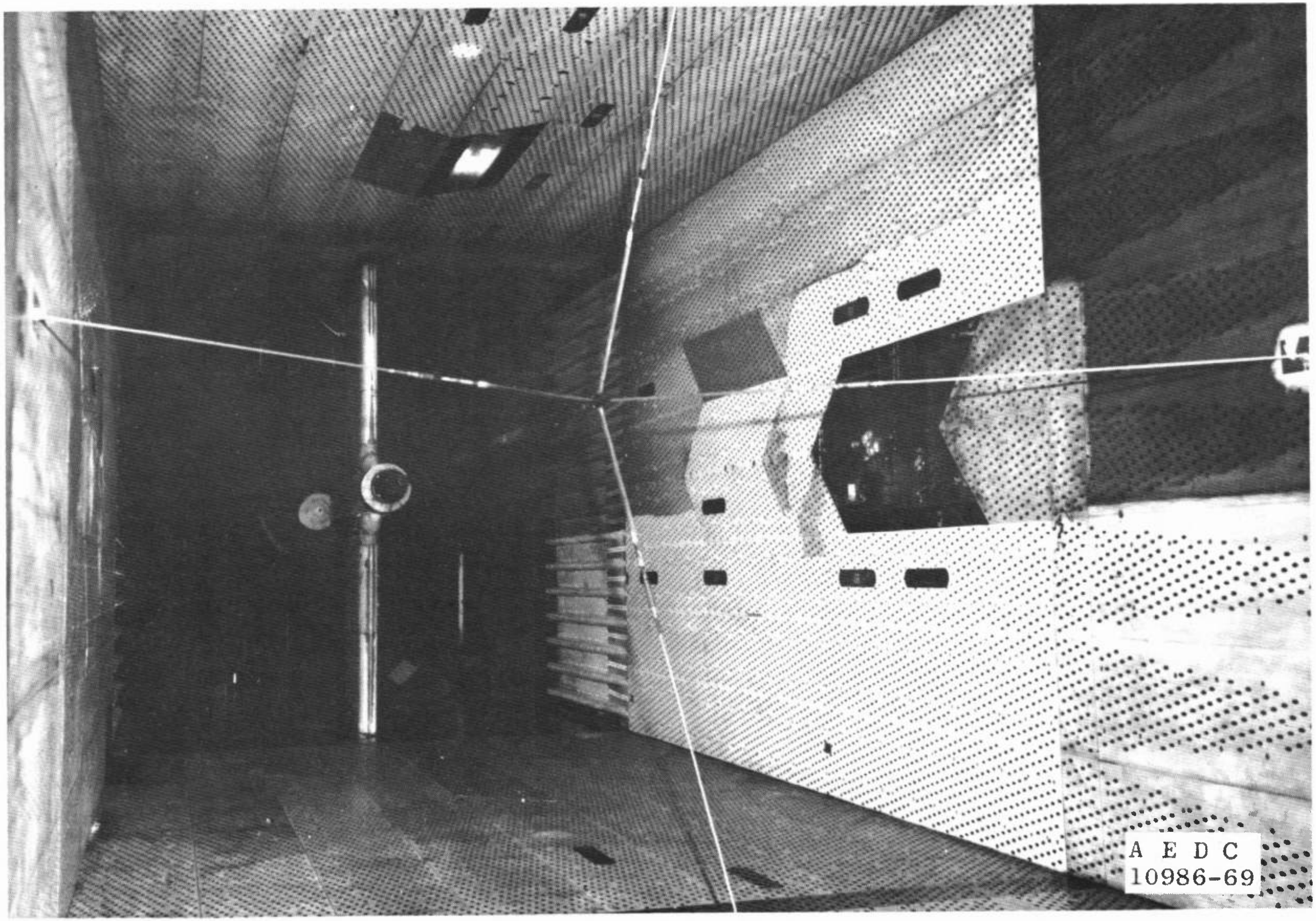
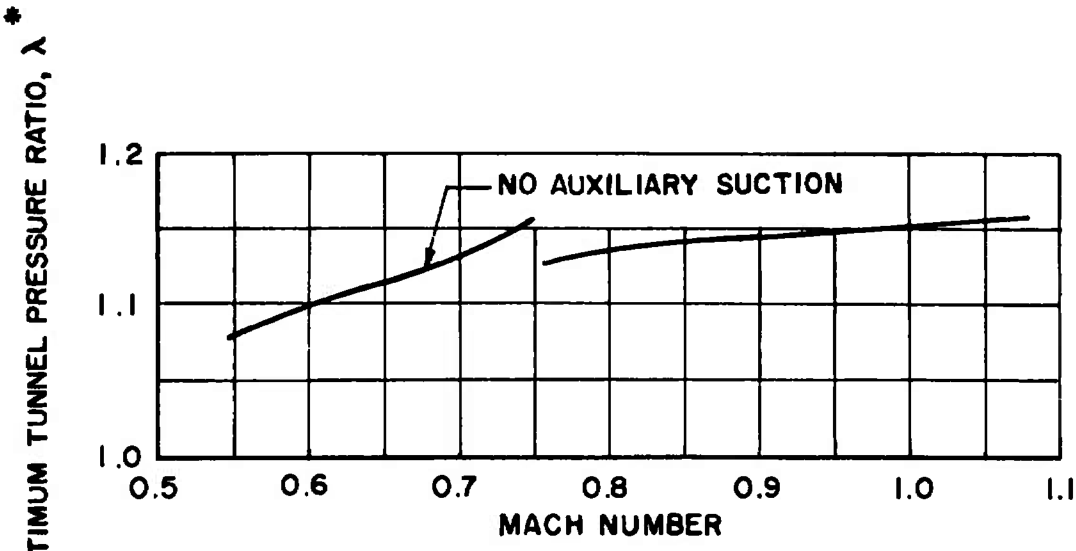
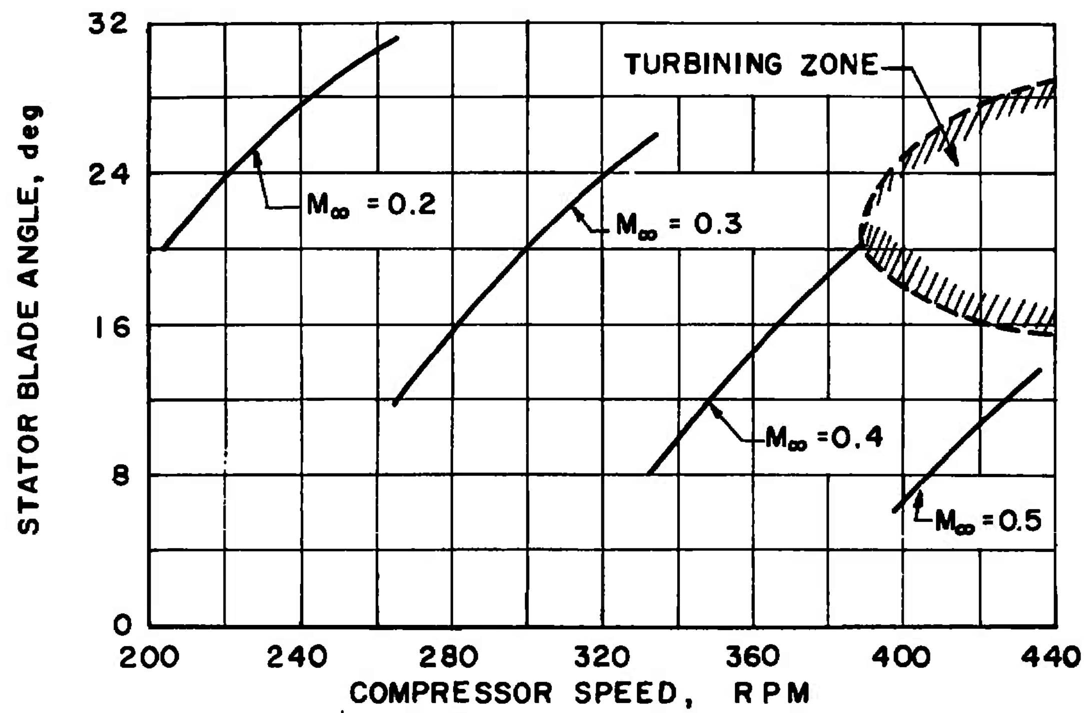


Fig. 2 Centerline Pipe Installation

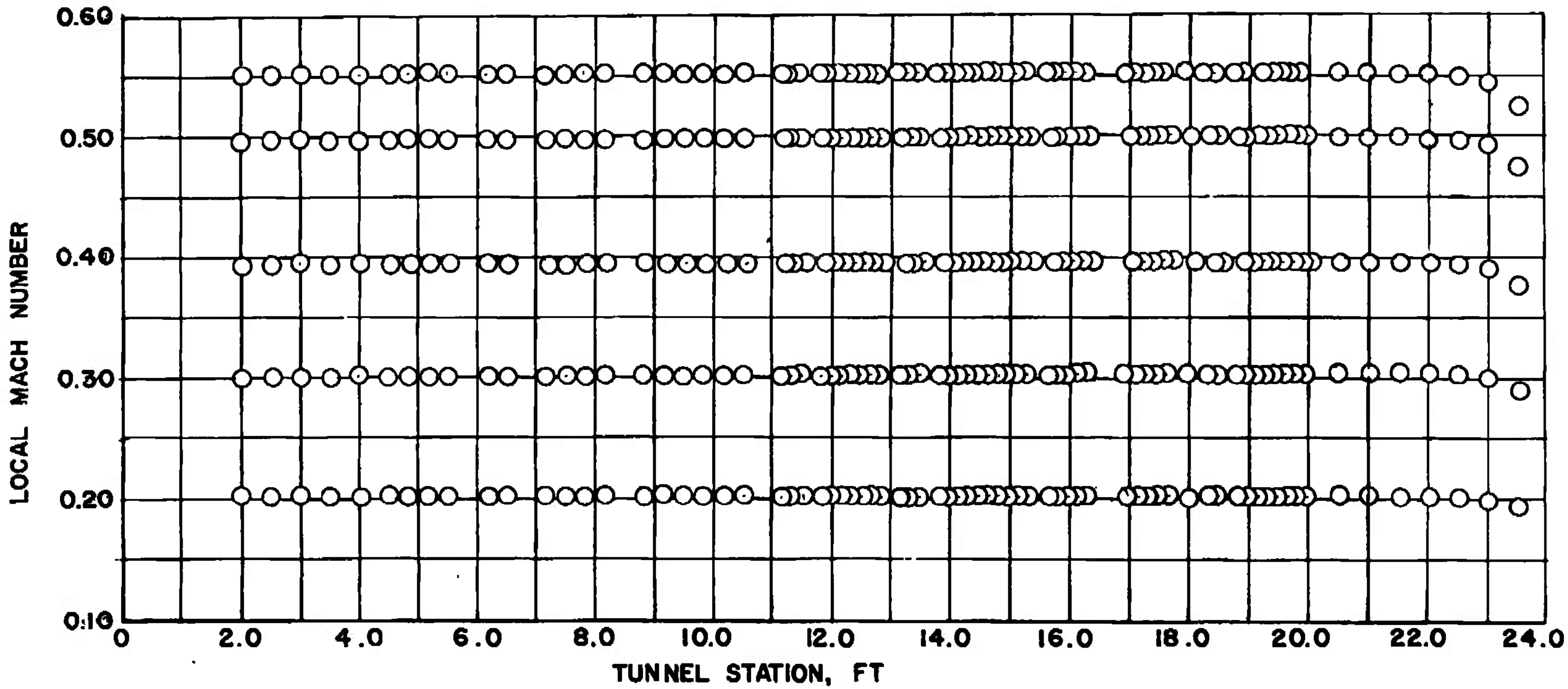


a. Synchronous Operation



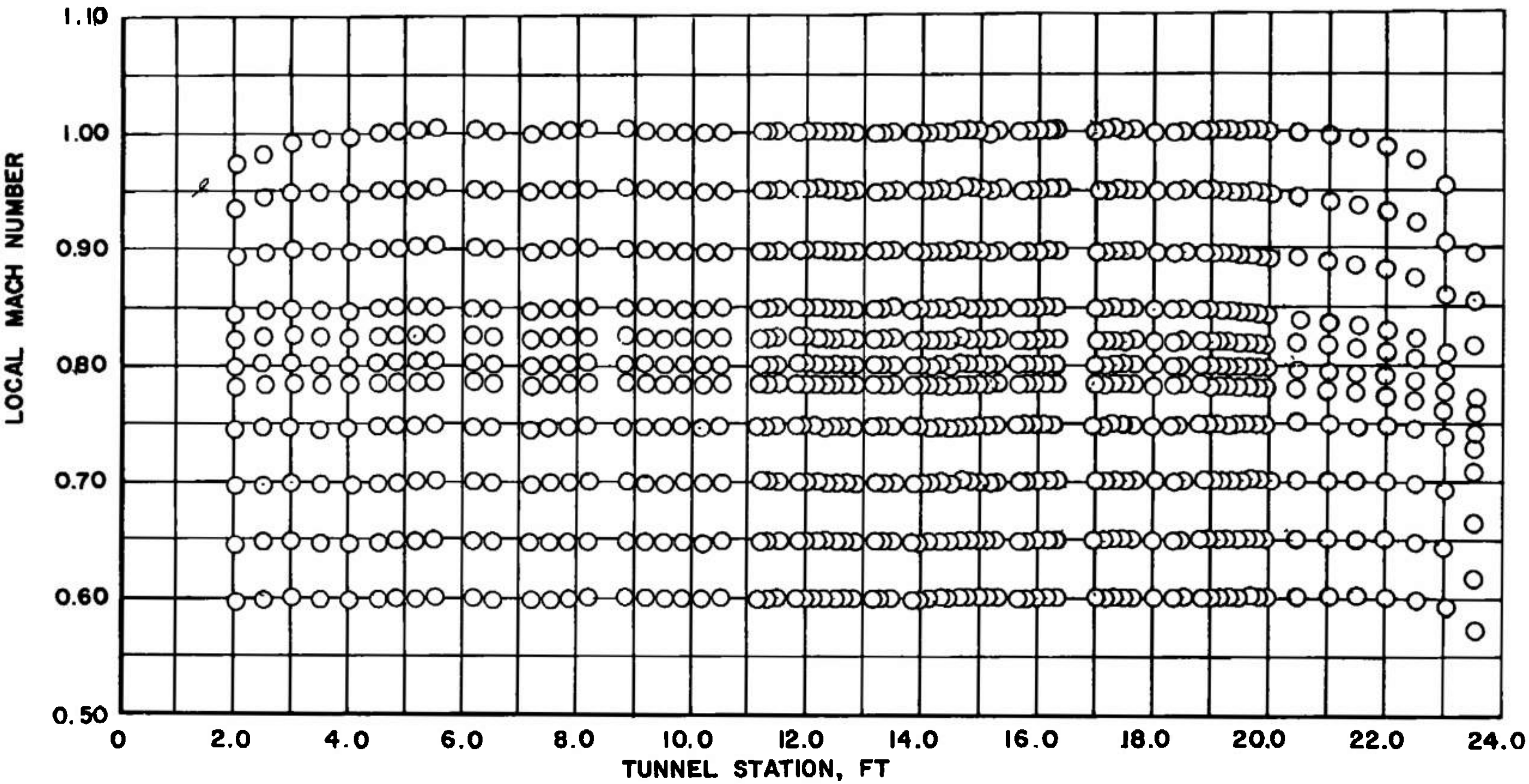
b. Subsynchronous Operation, T_t = 75°F

Fig. 3 Compressor Operating Conditions

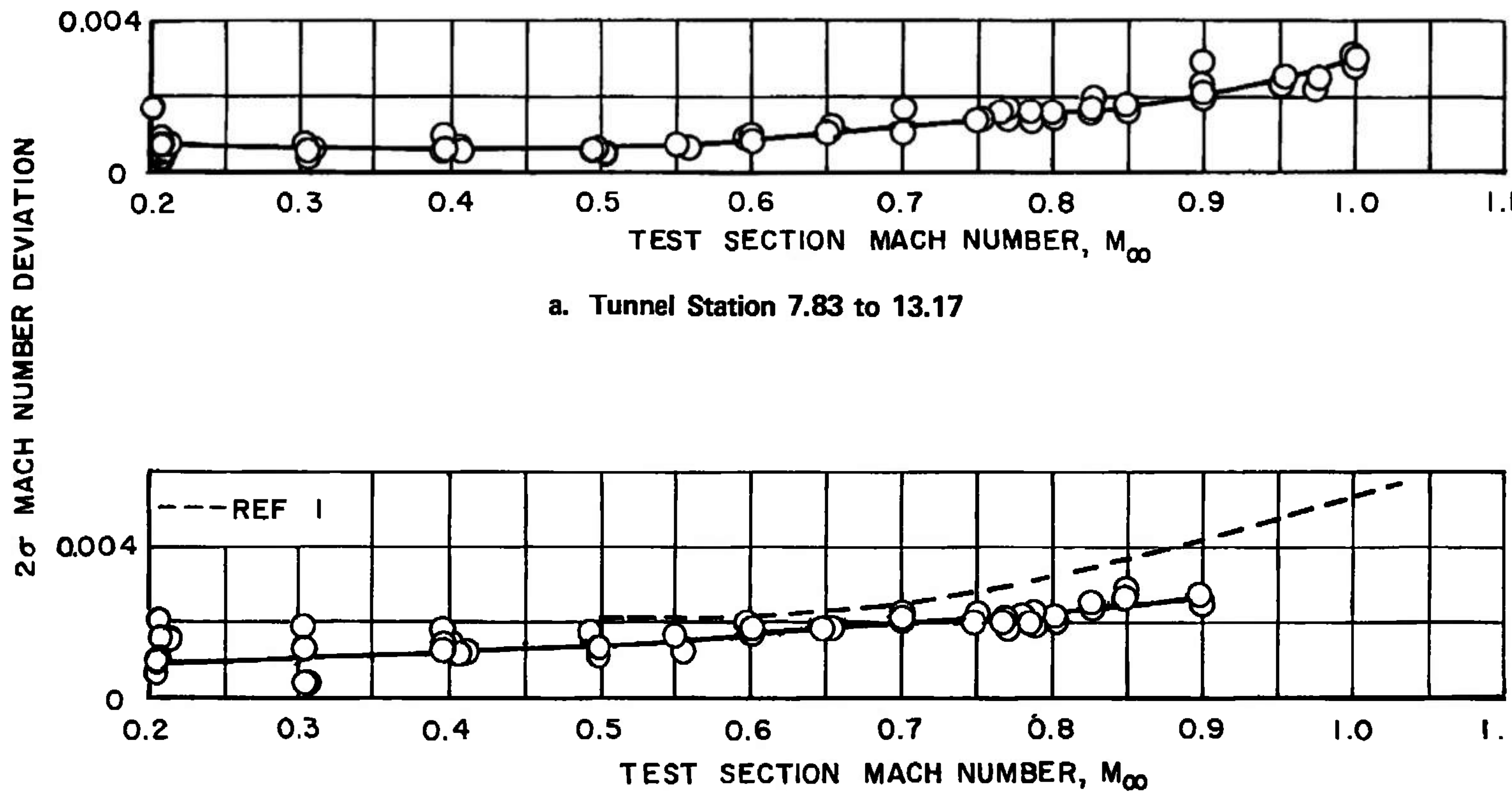


a. M_∞ = 0.202 to 0.553

Fig. 4 Centerline Mach Number Distributions for Various Test Section Mach Numbers at $\theta_w = 0$, $f_D = 0$, and $\lambda = \lambda^*$



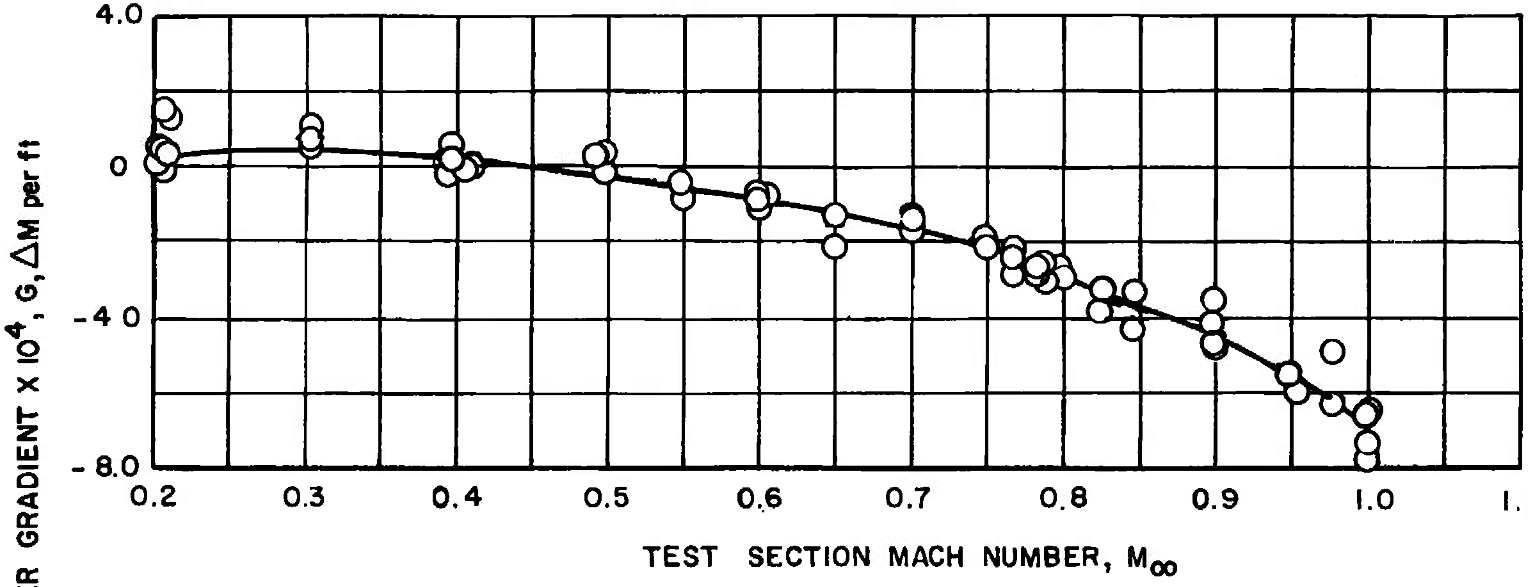
b. M_∞ = 0.601 to 1.000
Fig. 4 Concluded



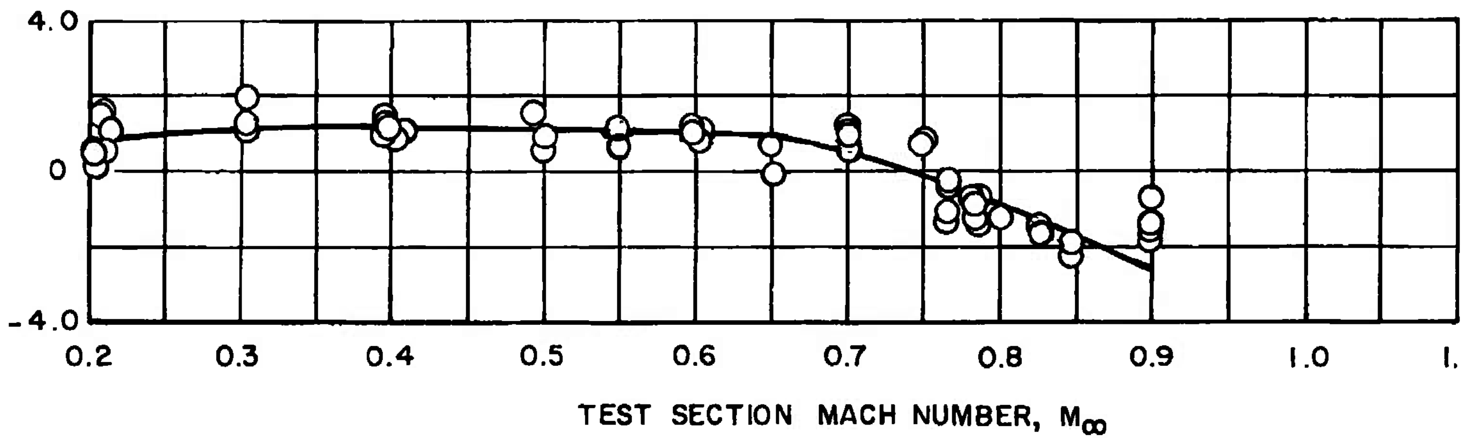
a. Tunnel Station 7.83 to 13.17

b. Tunnel Station 3.00 to 19.00

Fig. 5 Effect of Mach Number upon the Mach Number Deviations at $\theta_w = 0$, $f_D = 0$, and $\lambda = \lambda^*$

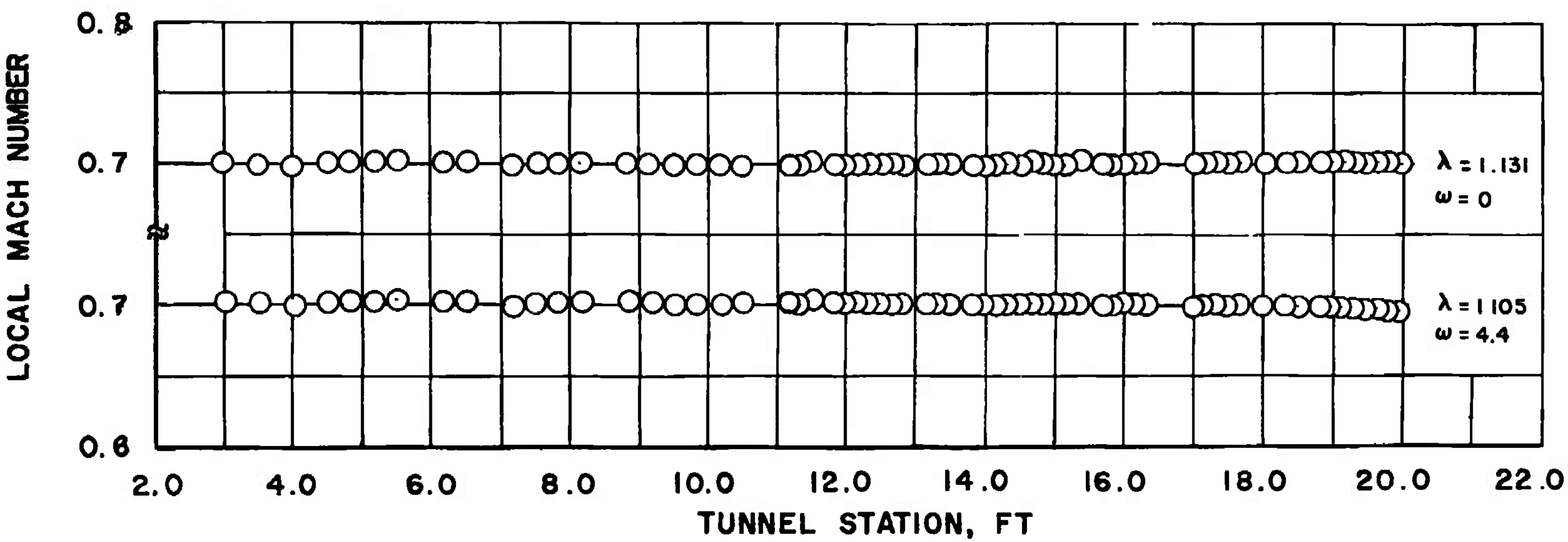


a. Tunnel Station 7.83 to 13.17



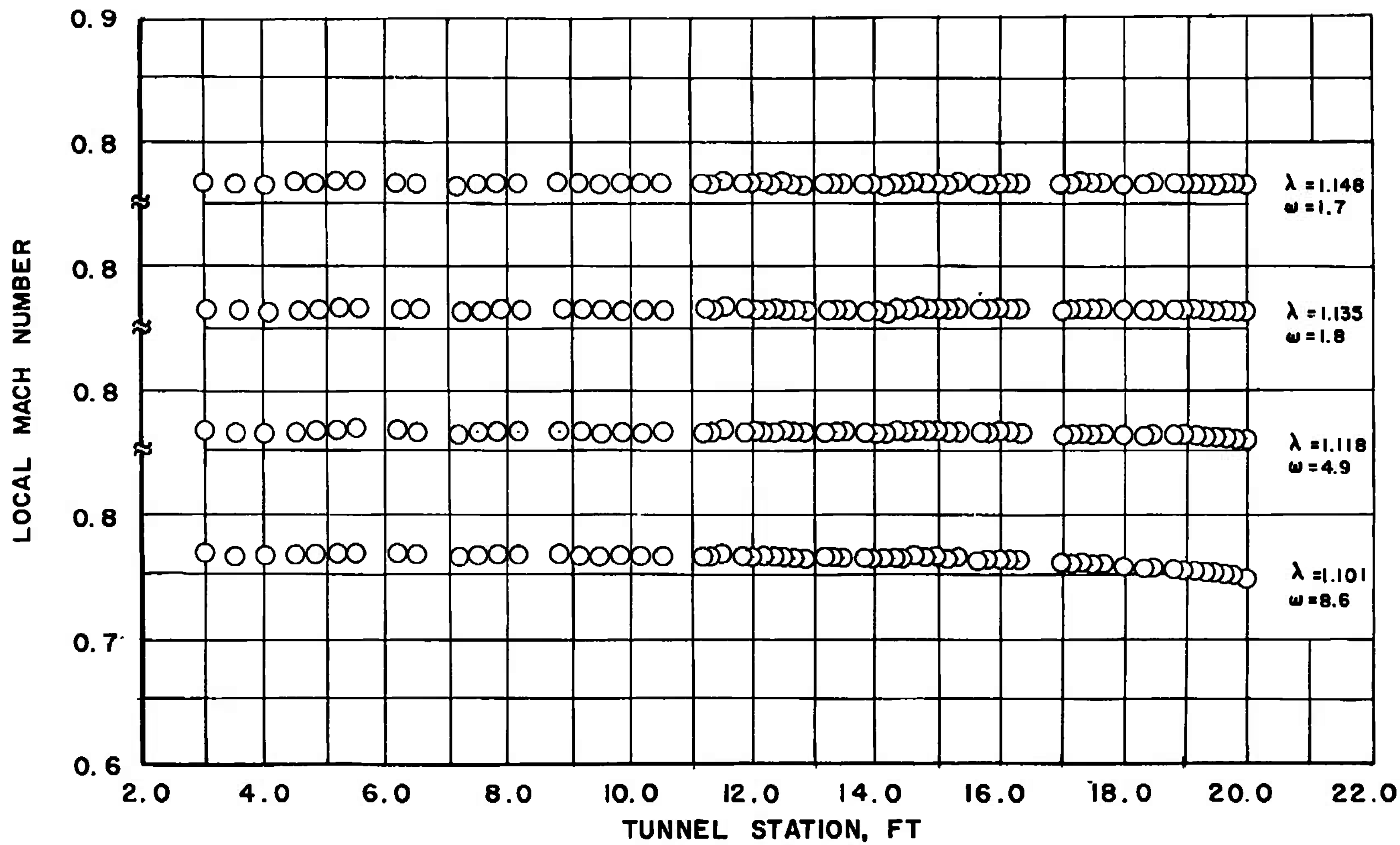
b. Tunnel Station 3.00 to 19.00

Fig. 6 Effect of Mach Number upon the Mach Number Gradients at $\theta_w = 0$, $f_D = 0$, and $\lambda = \lambda^*$



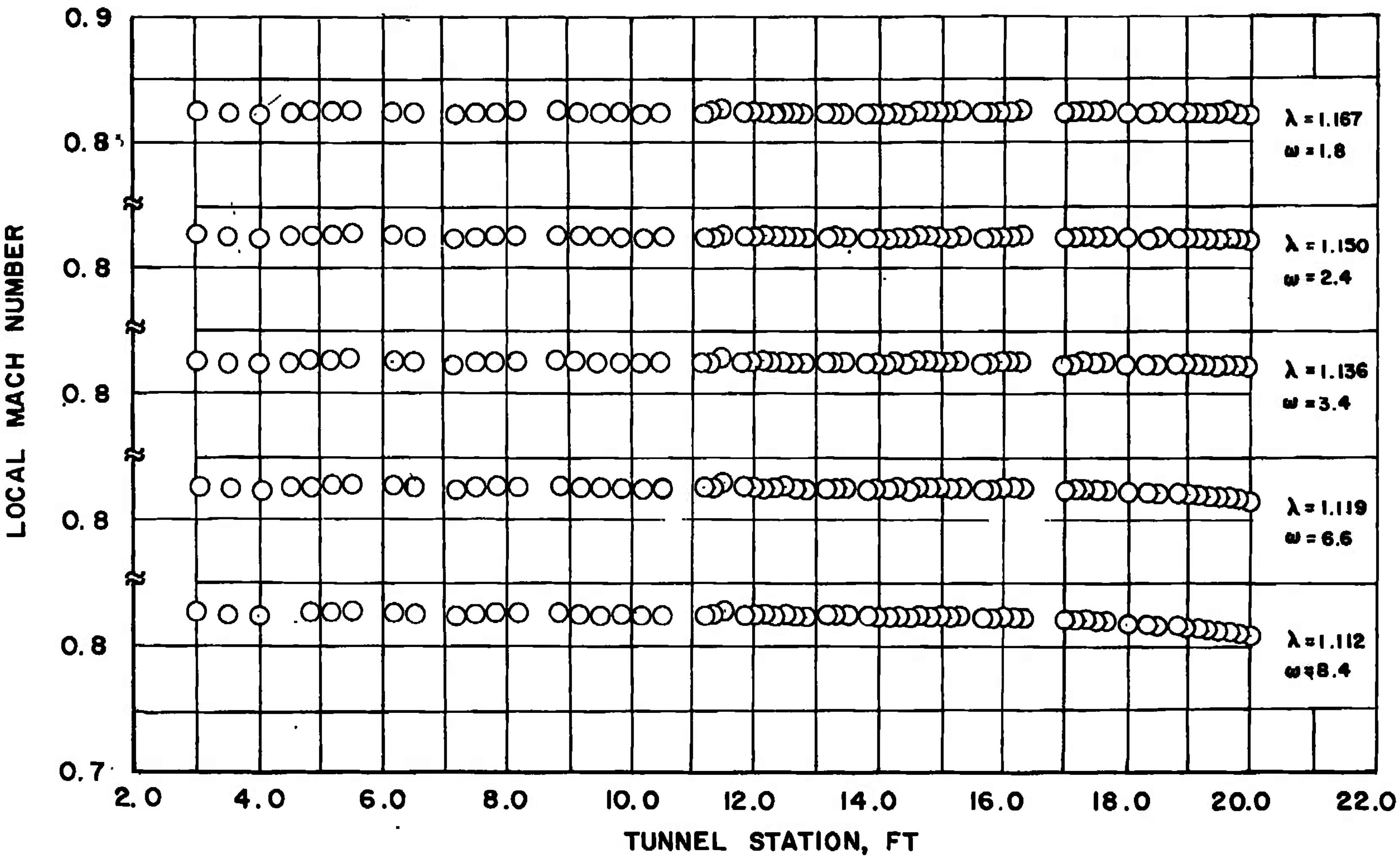
a. M = 0.700

Fig. 7 Centerline Mach Number Distributions for Various Tunnel Pressure Ratios at θ_w = 0 and f_D = 0

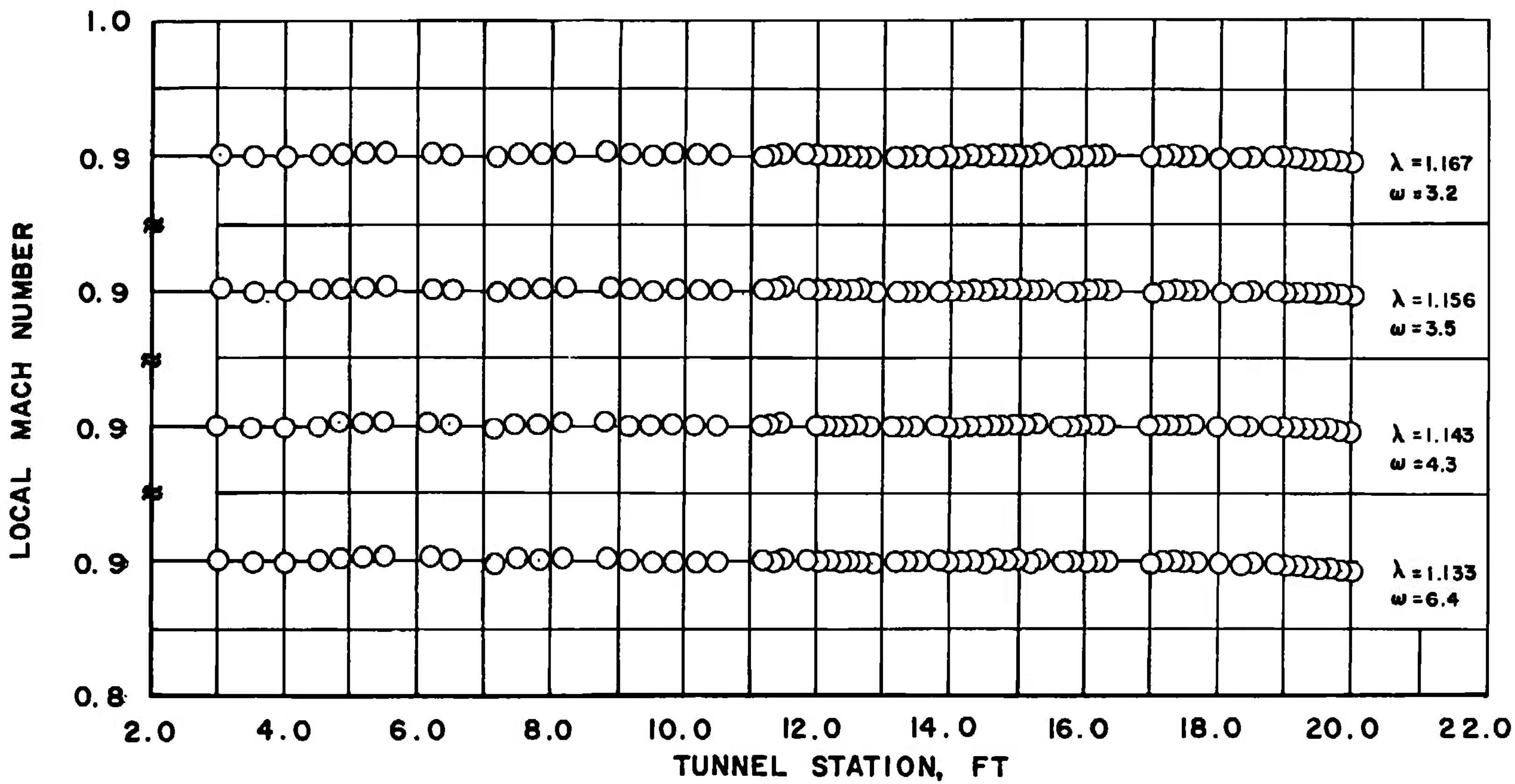


b. M = 0.767

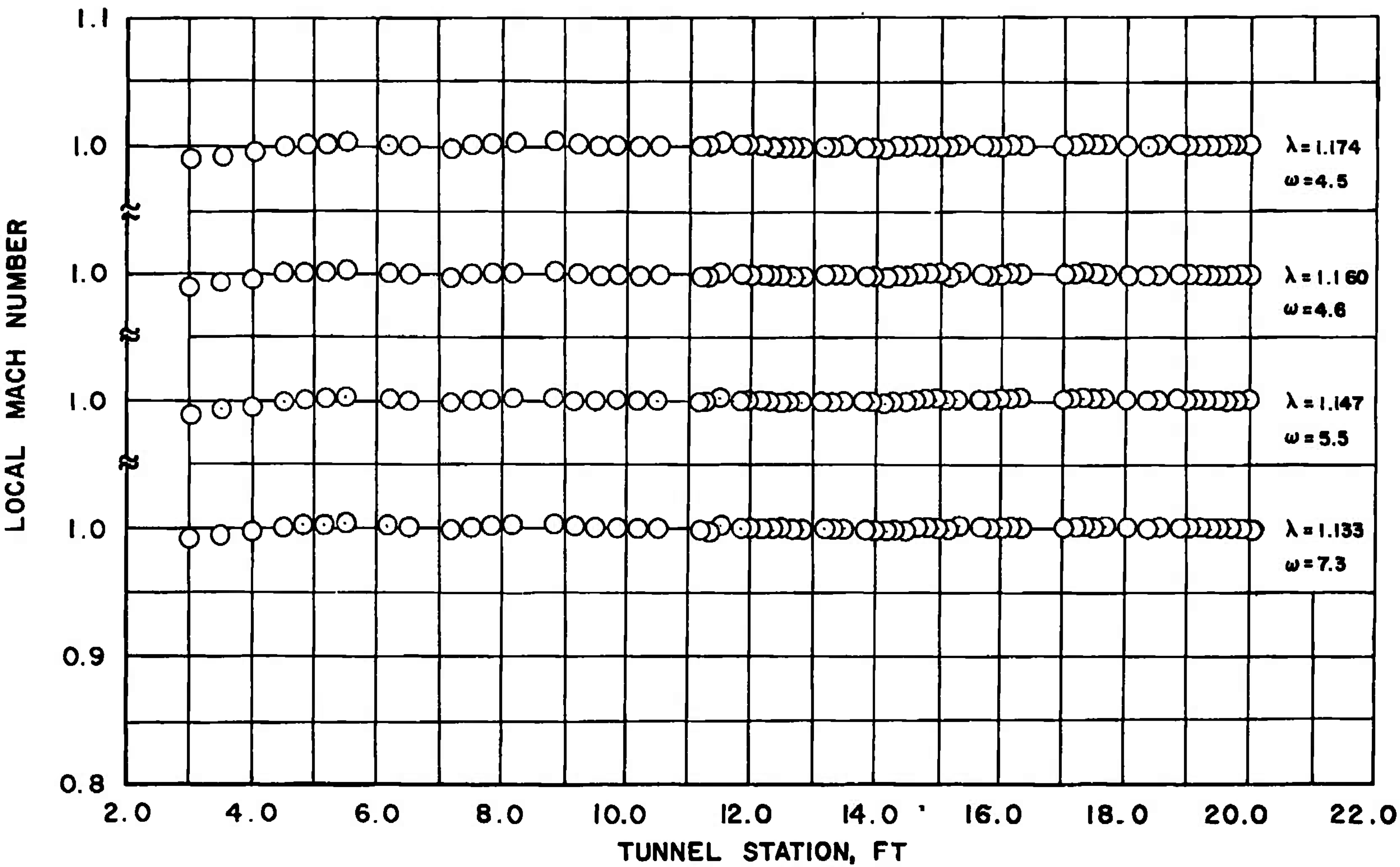
Fig. 7 Continued



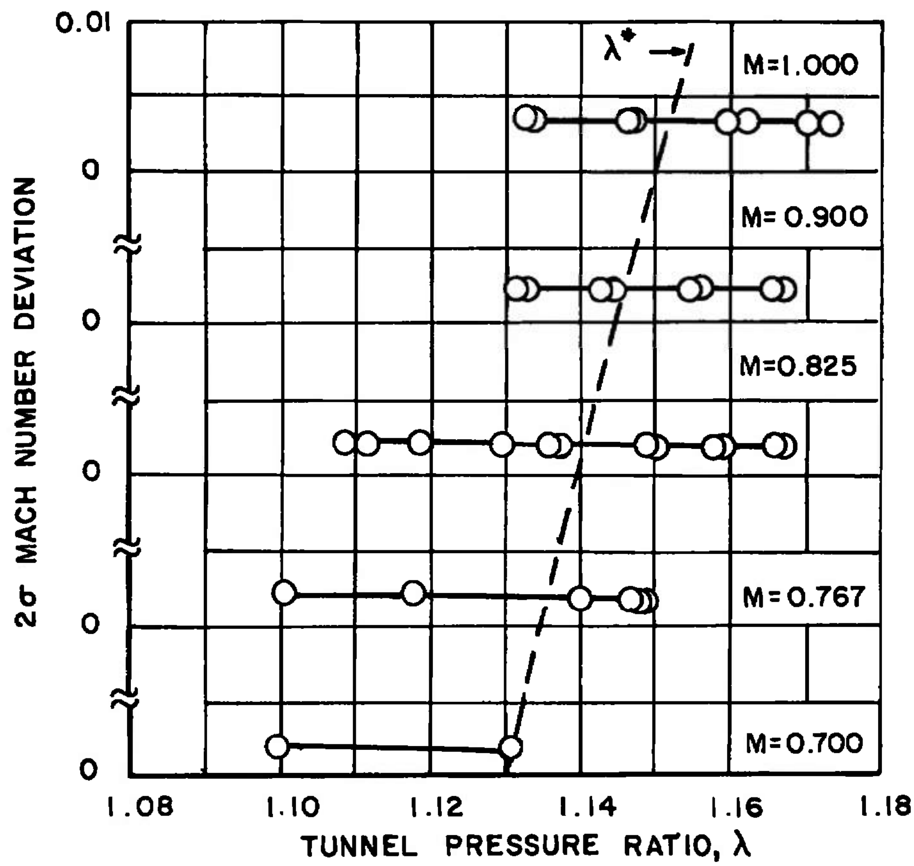
c. M = 0.825
Fig. 7 Continued



d. M = 0.900
Fig. 7 Continued

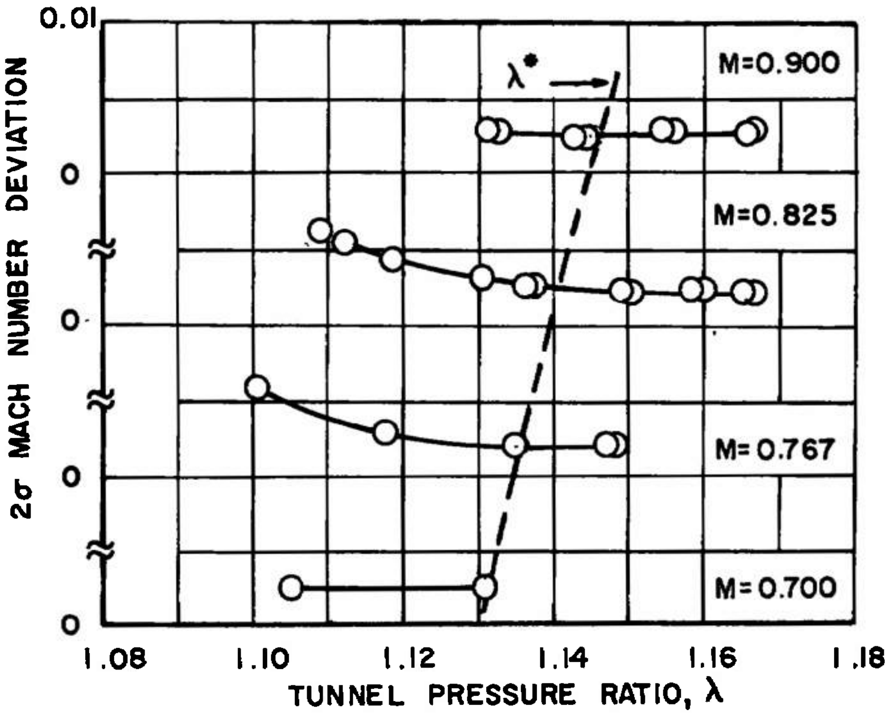


e. M = 1.000
Fig. 7 Concluded

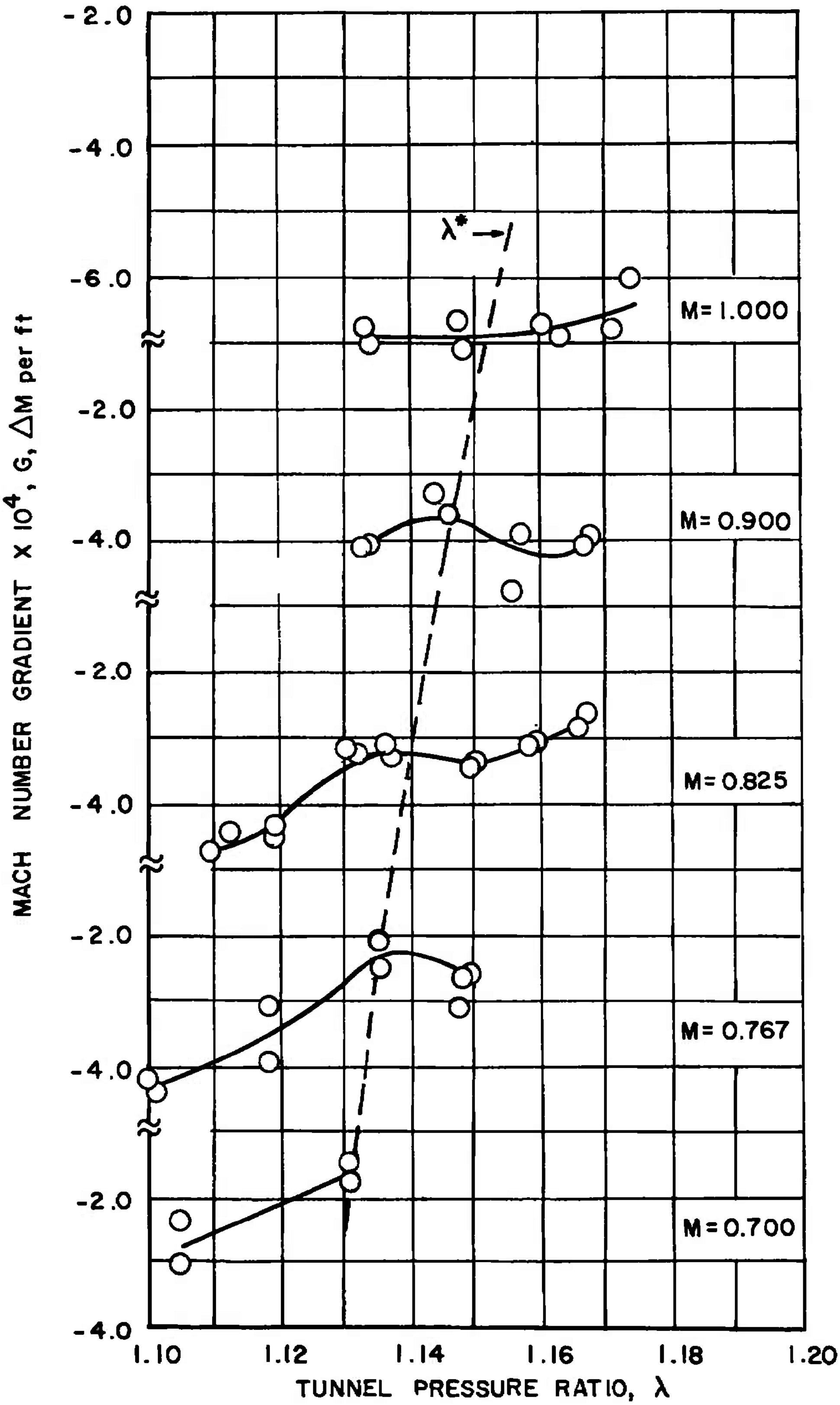


a. Tunnel Station 7.83 to 13.17

Fig. 8 Effect of Pressure Ratio upon the Mach Number Deviations at $\theta_w = 0$ and $f_D = 0$

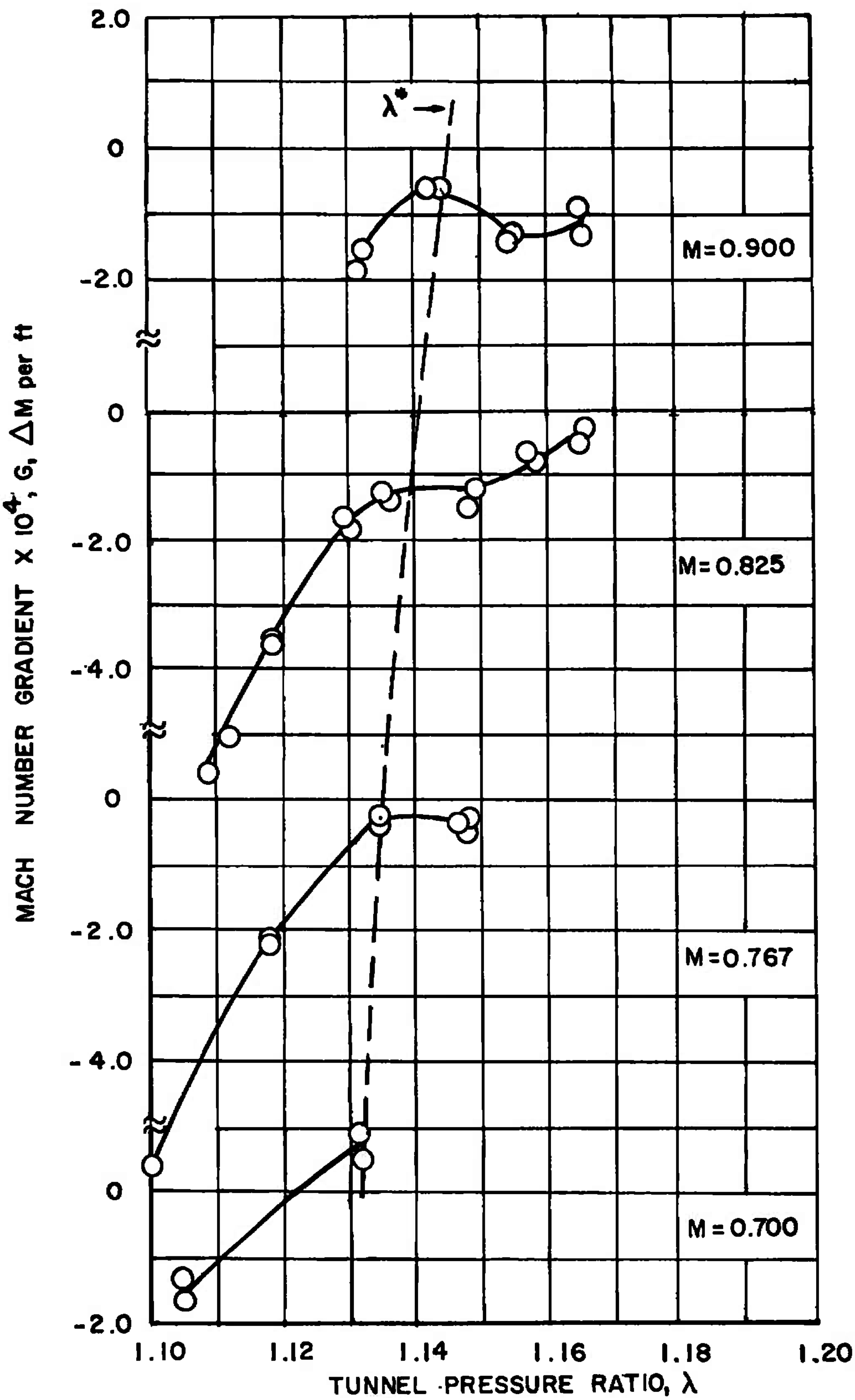


b. Tunnel Station 3.00 to 19.00
Fig. 8 Concluded

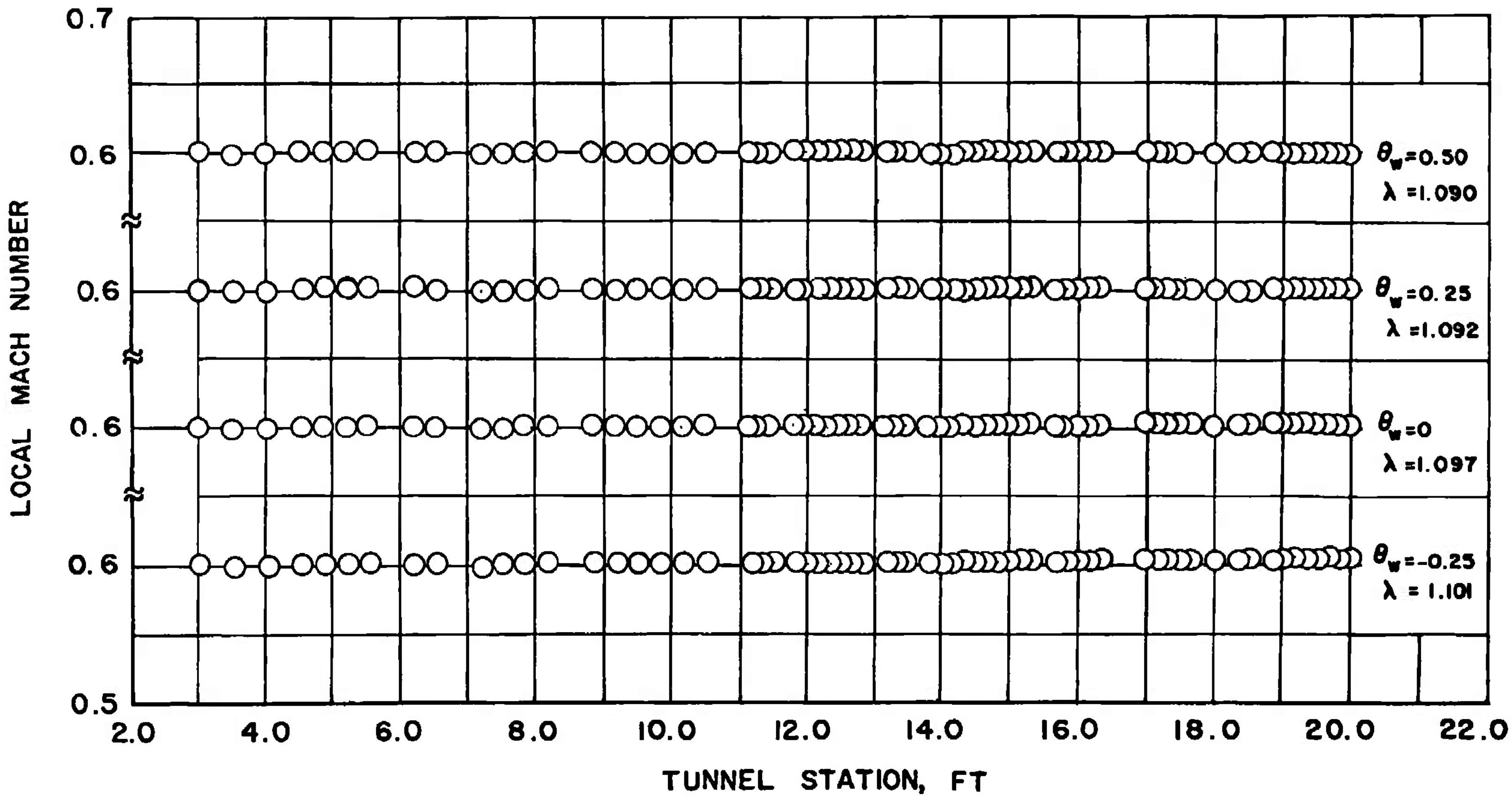


a. Tunnel Station 7.83 to 13.17

Fig. 9 Effect of Pressure Ratio upon the Mach Number Gradients at θ_w = 0 and f_D = 0

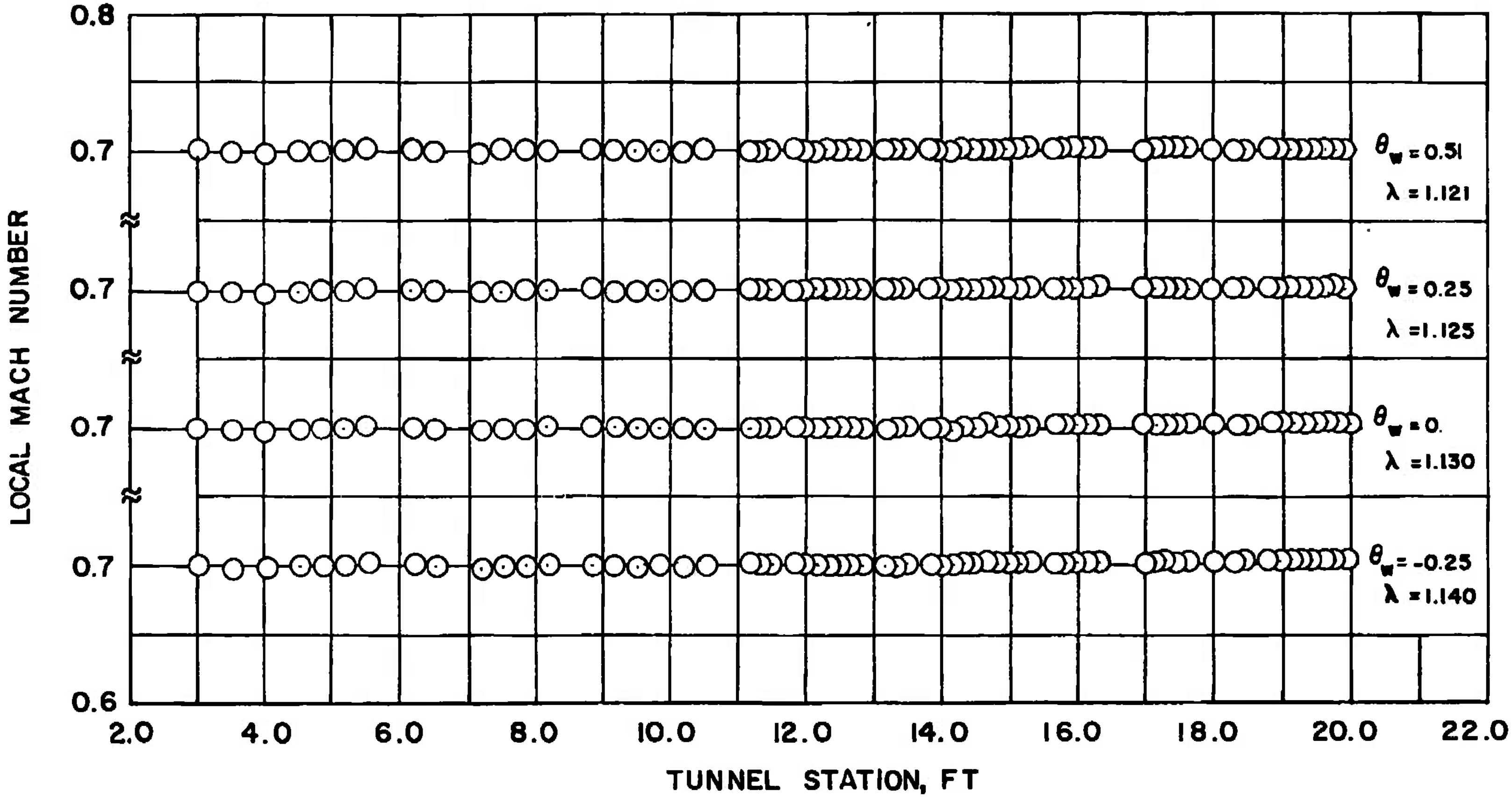


b. Tunnel Station 3.00 to 19.00
Fig. 9 Concluded

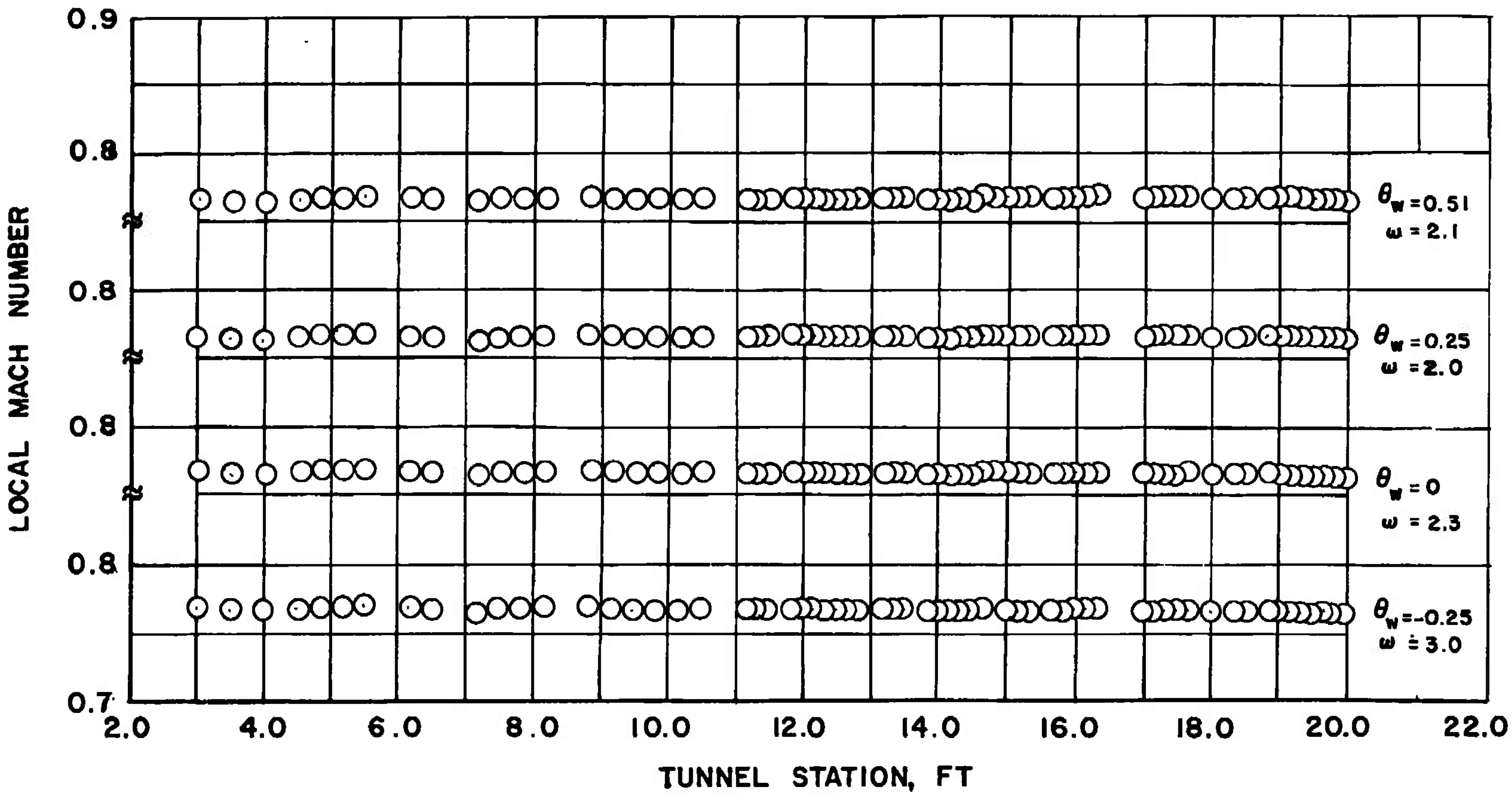


a. M = 0.600, ω = 0

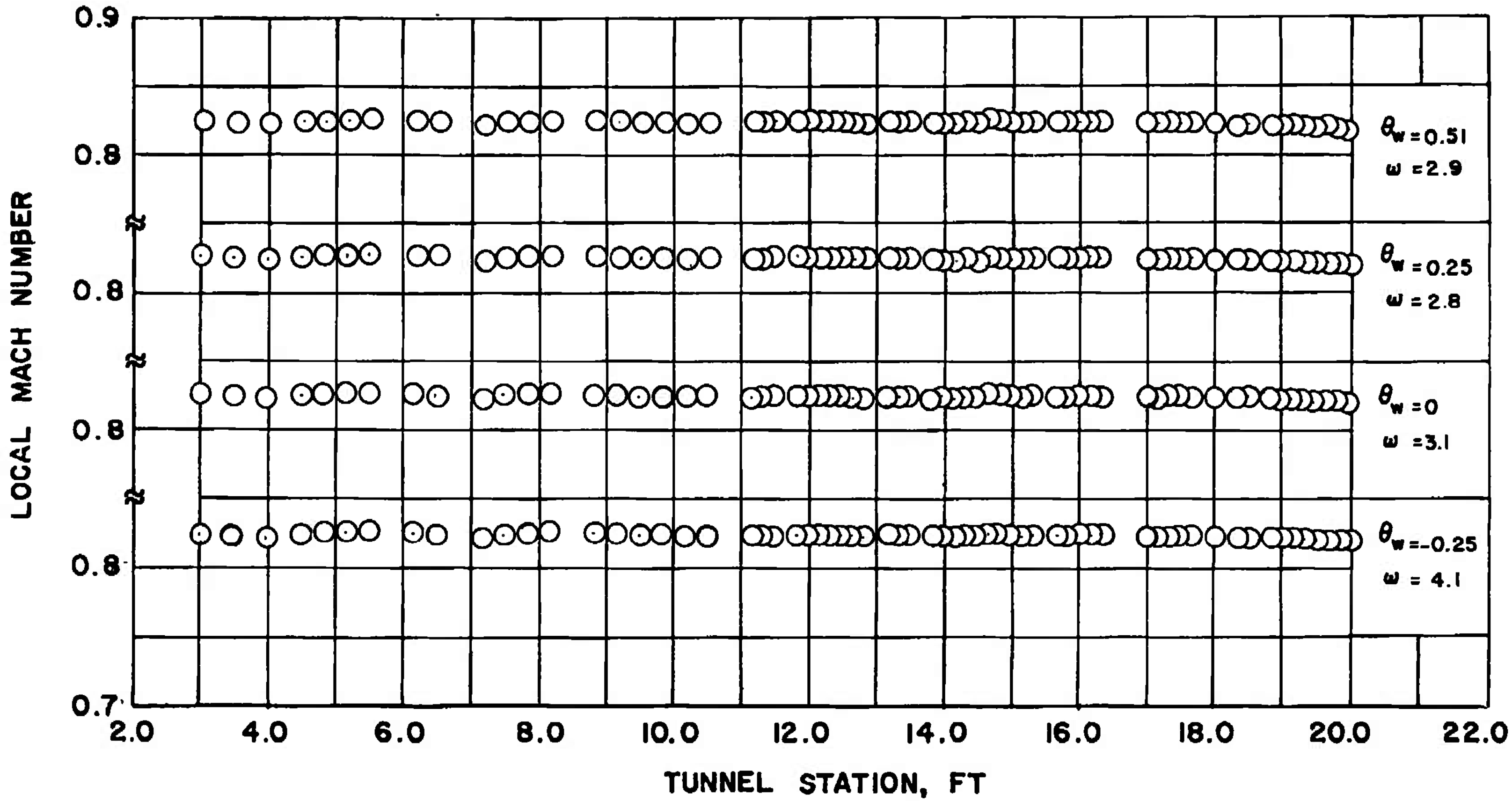
Fig. 10 Centerline Mach Number Distributions for Various Test Section Wall Angles at f_D = 0



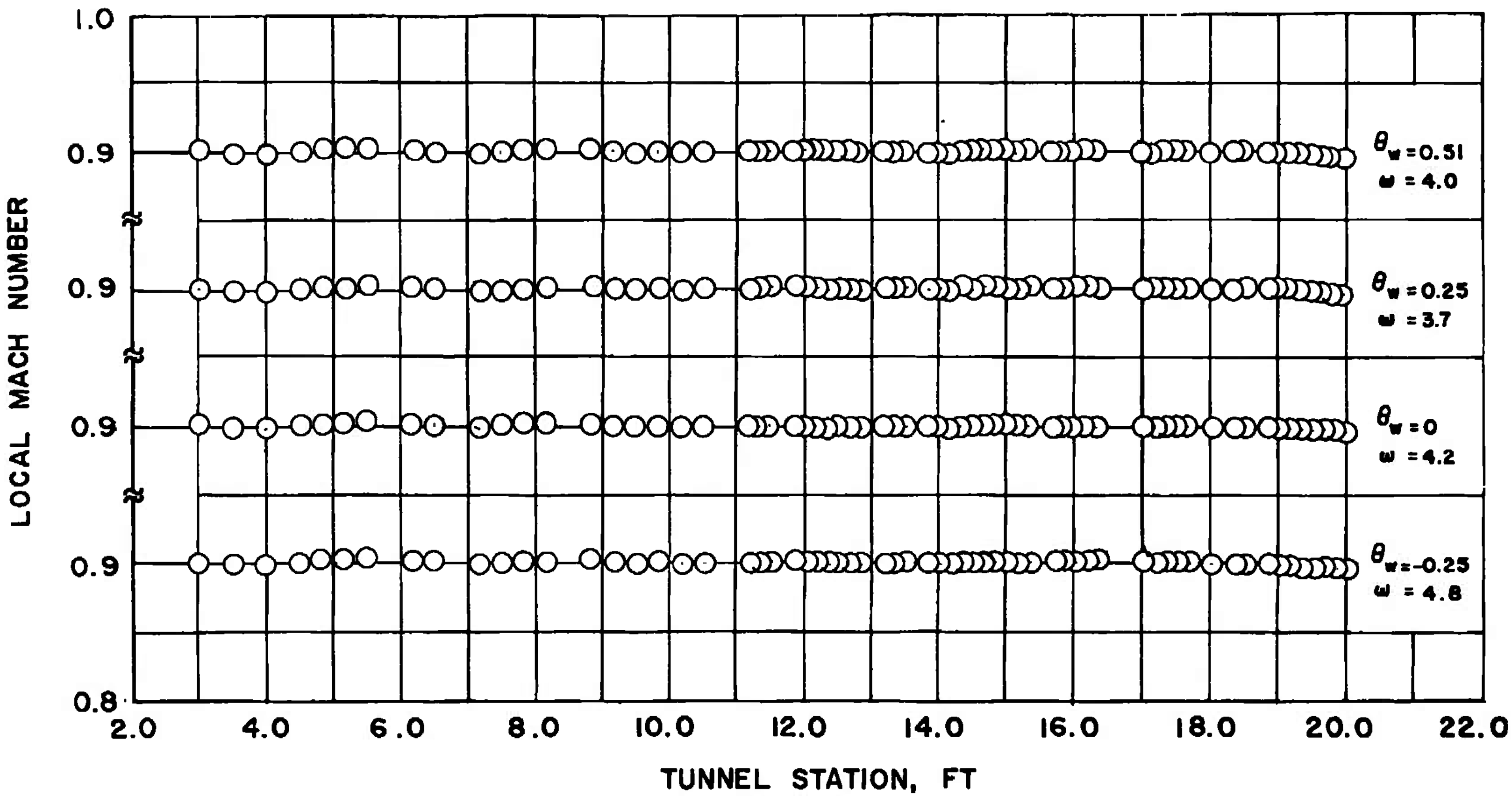
b. M = 0.700, ω = 0
Fig. 10 Continued



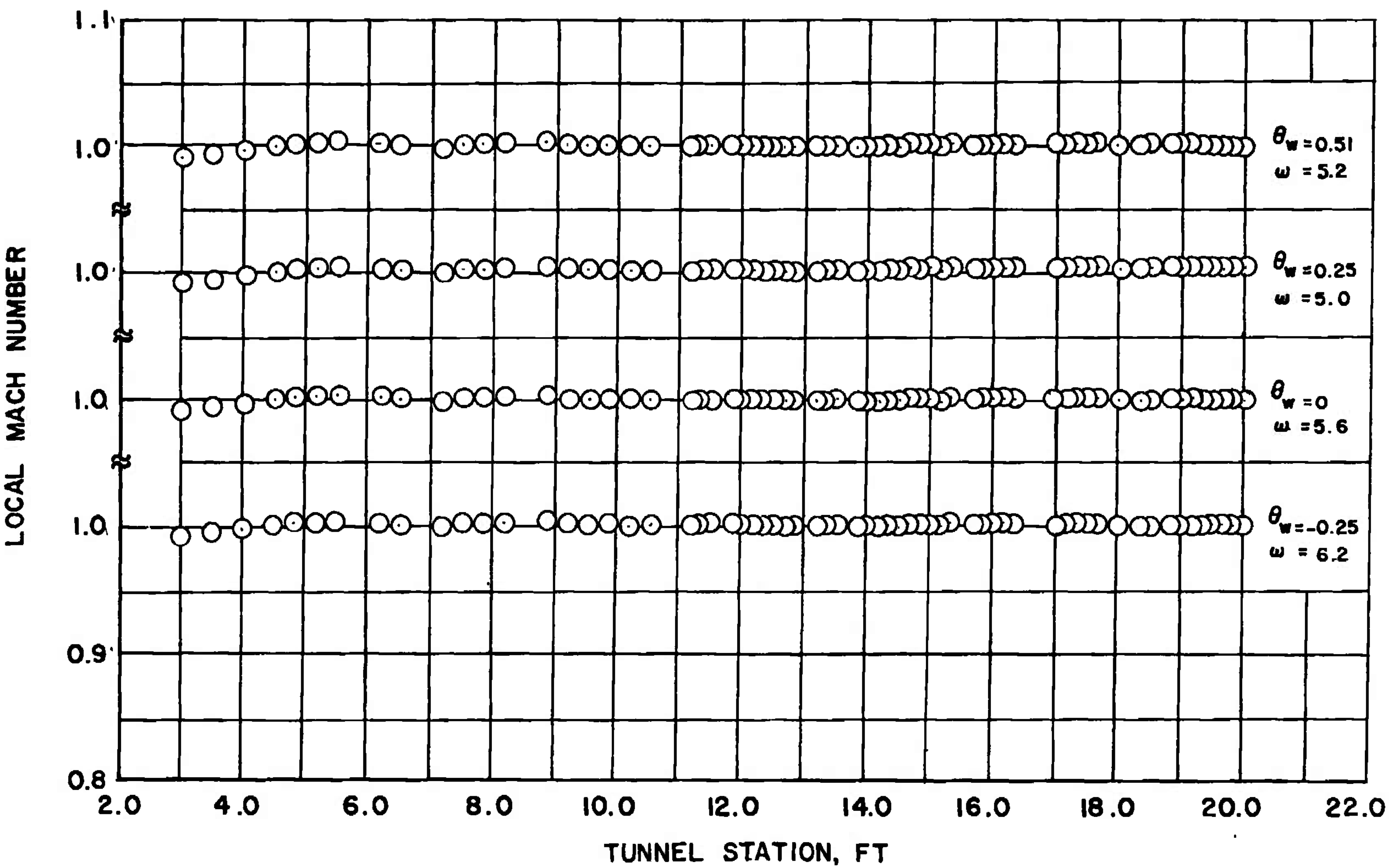
c. M = 0.767, λ = 1.135
Fig. 10 Continued



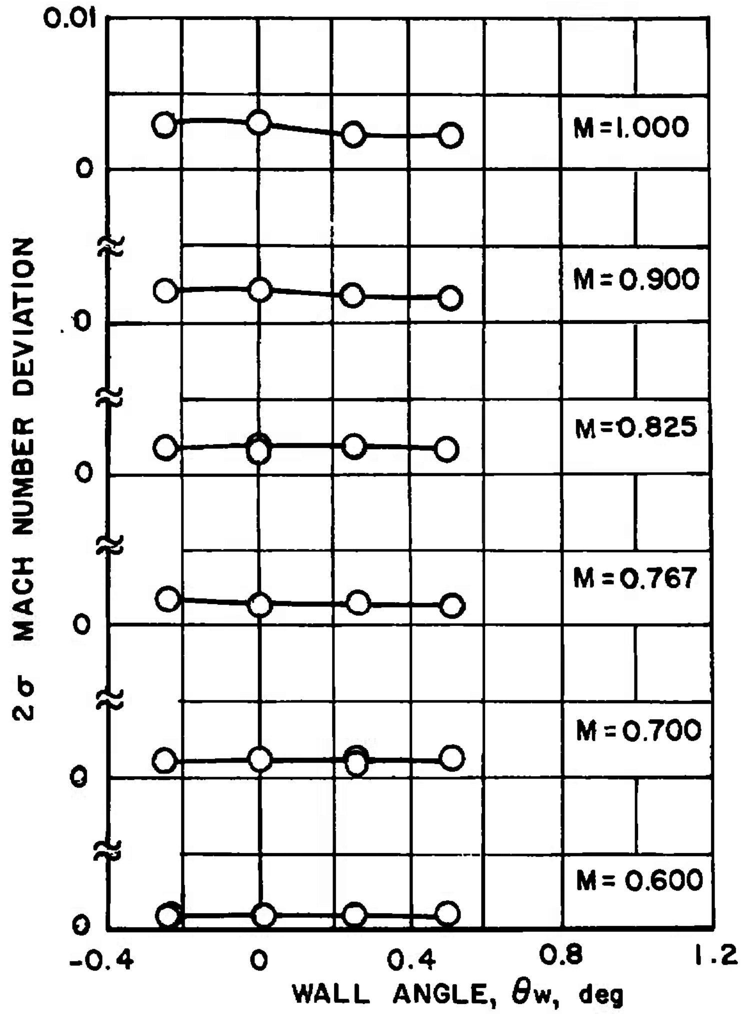
d. M = 0.825, λ = 1.140
Fig. 10 Contined



e. M = 0.900, λ = 1.148
Fig. 10 Continued

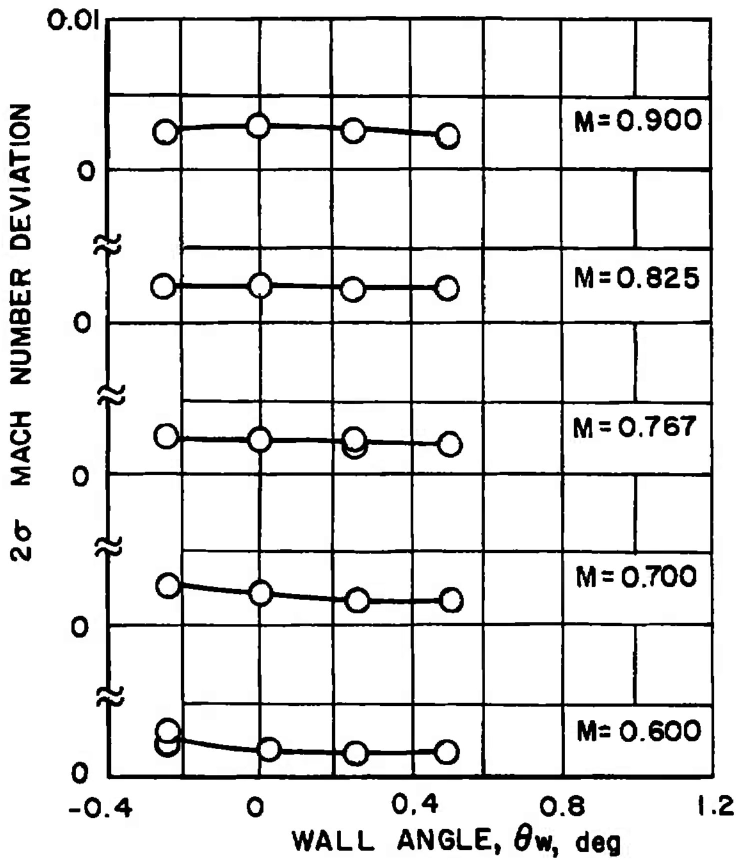


f. M = 1.000, λ = 1.152
Fig. 10 Concluded

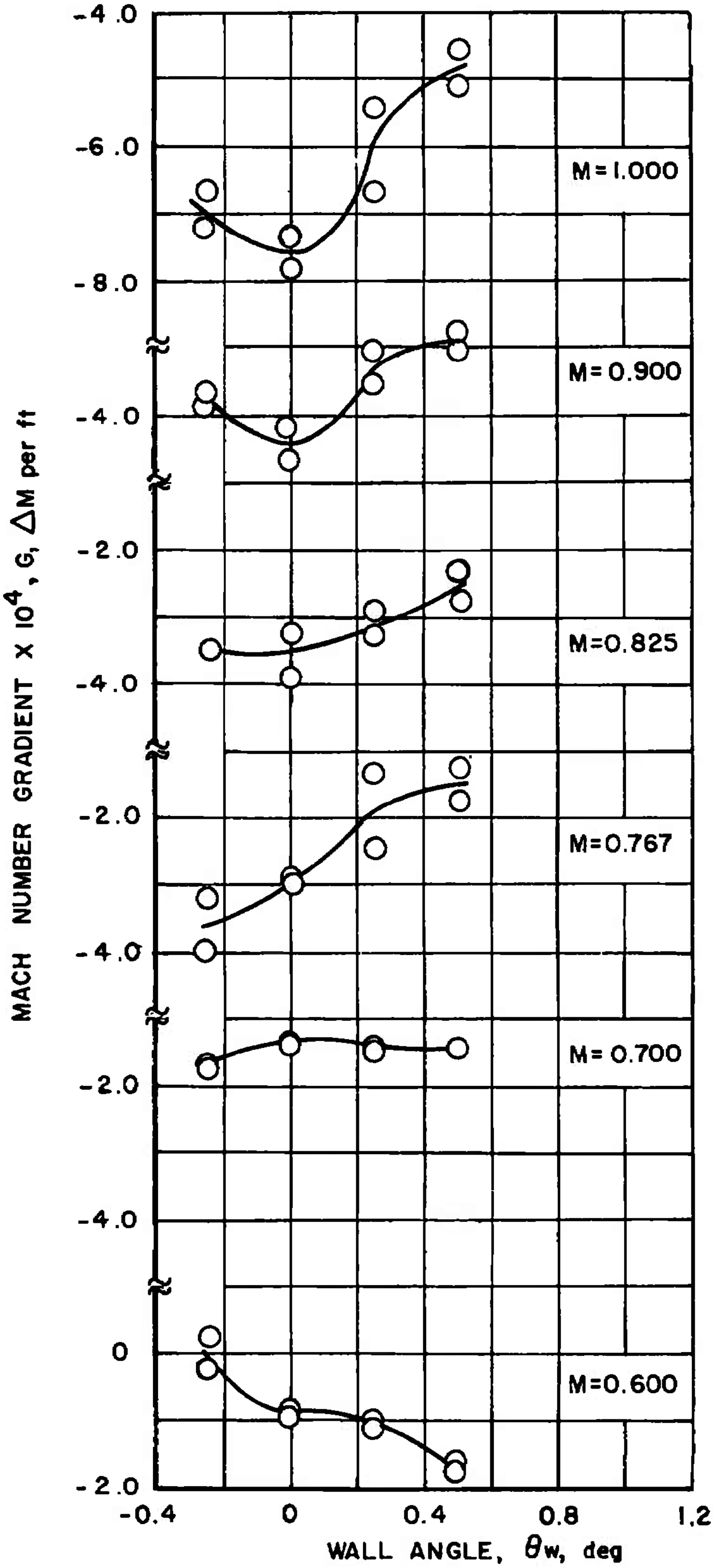


a. Tunnel Station 7.83 to 13.17

Fig. 11 Effect of Wall Angle on the Mach Number Deviations at $f_D = 0$ and $\lambda = \lambda^*$

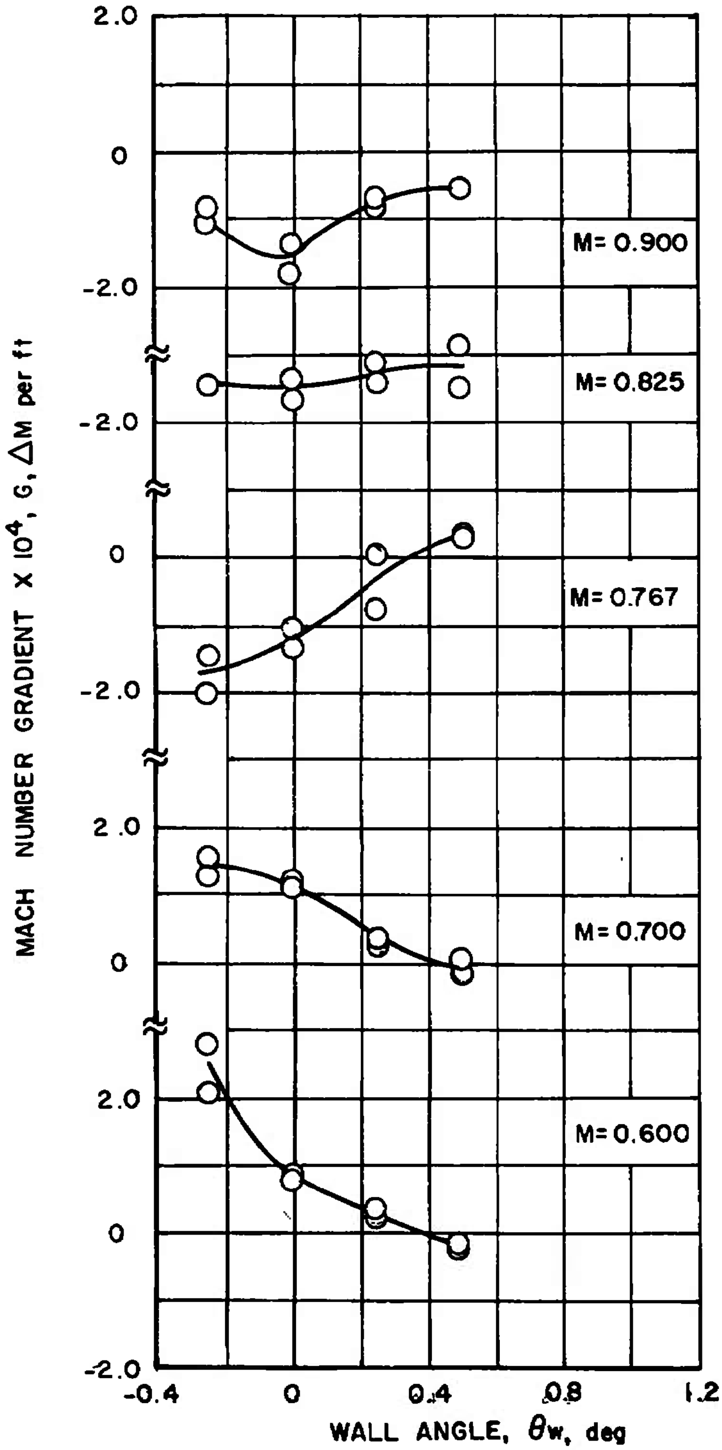


b. Tunnel Station 3.00 to 19.00
Fig. 11 Concluded

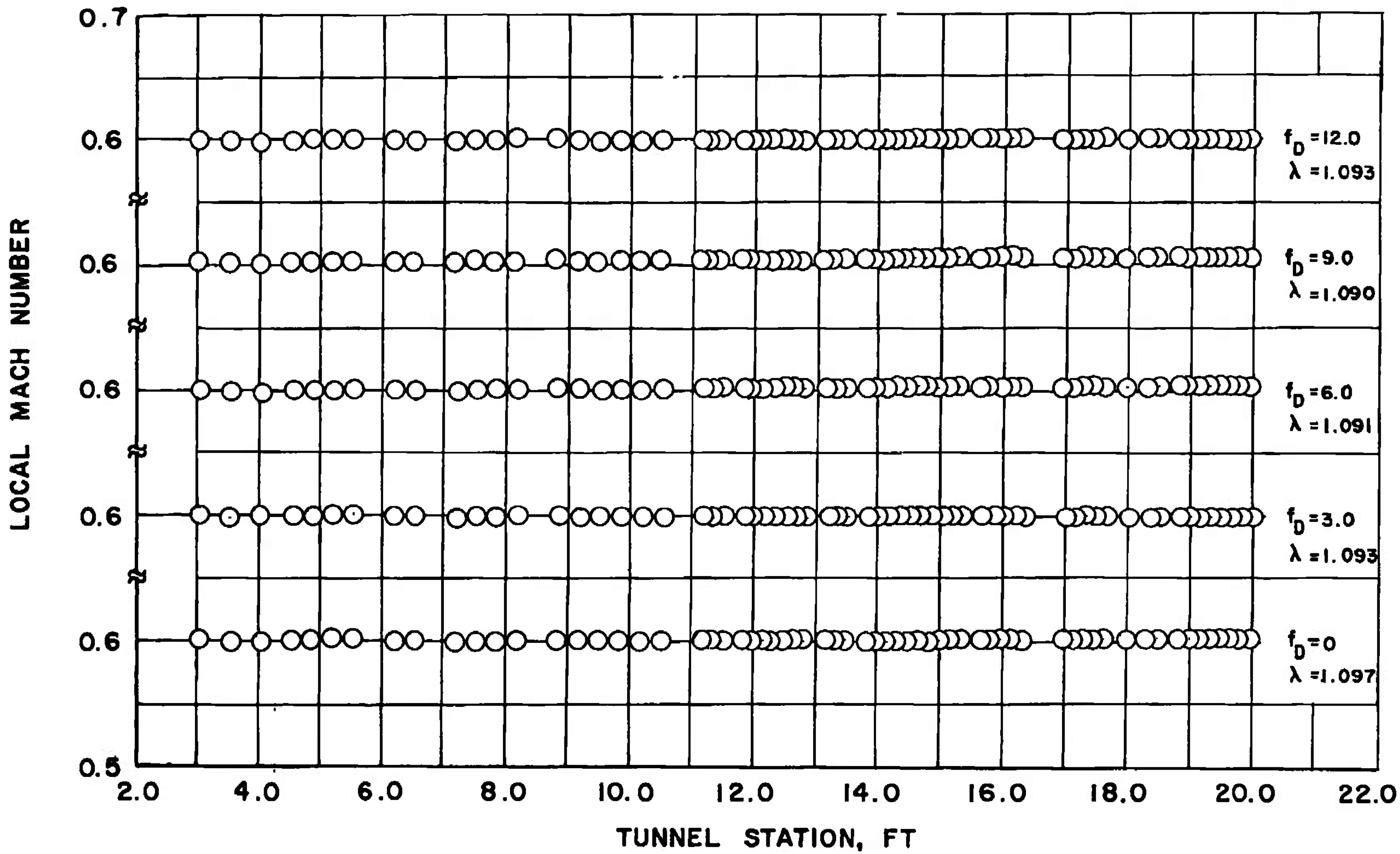


a. Tunnel Station 7.83 to 13.17

Fig. 12 Effect of Wall Angle upon the Mach Number Gradients at f_D = 0 and $\lambda = \lambda^*$

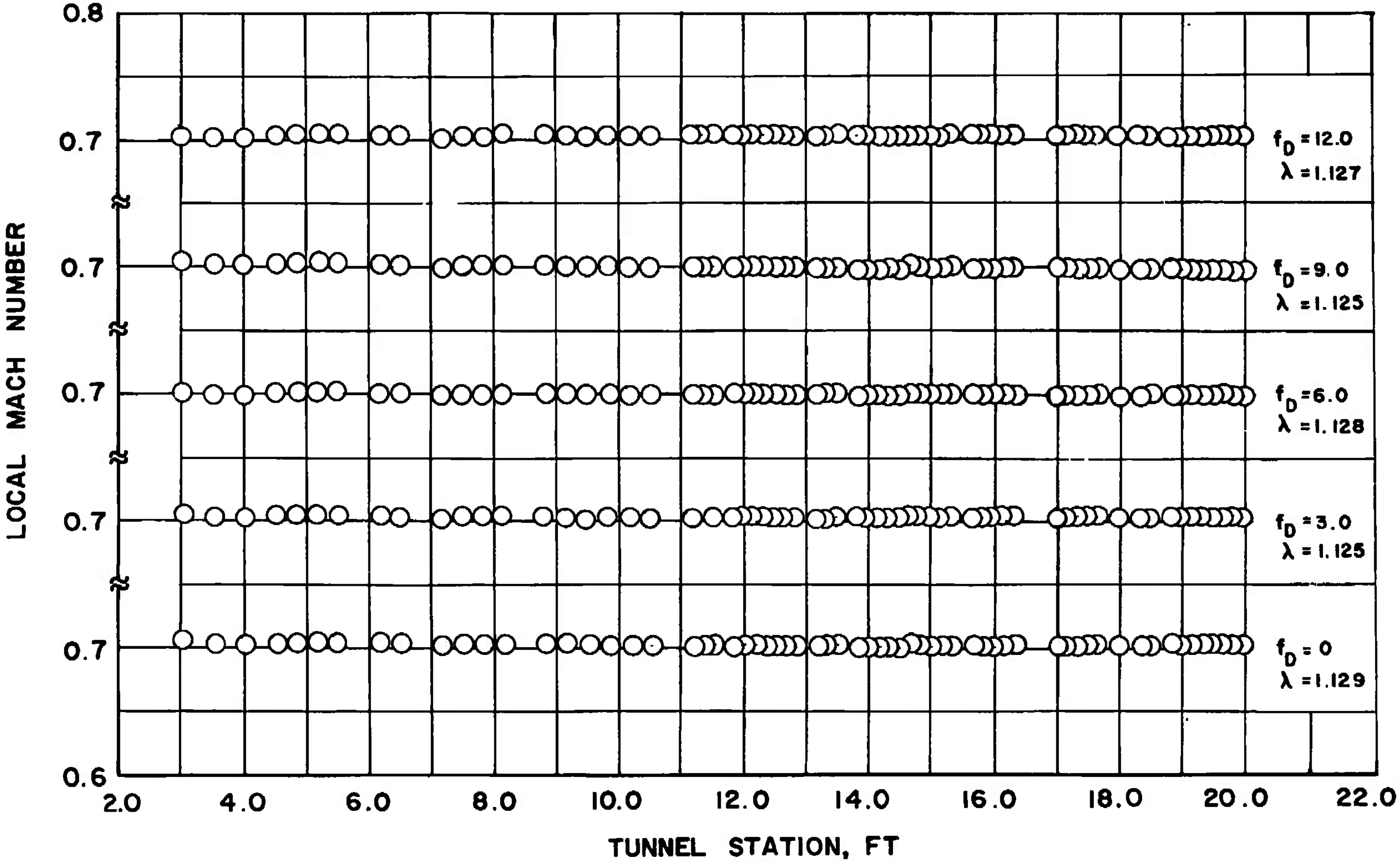


b. Tunnel Station 3.00 to 19.00
Fig. 12 Concluded

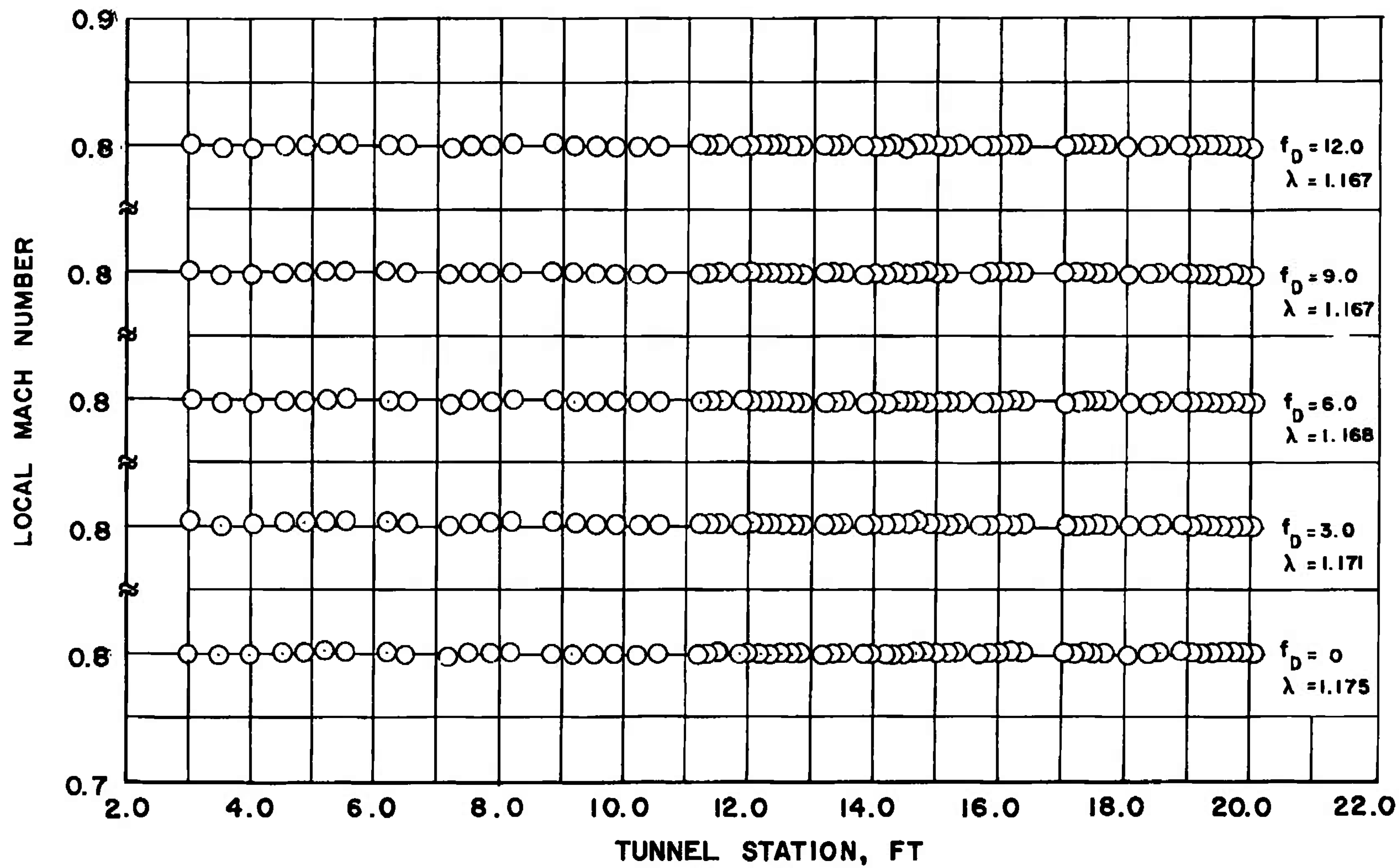


a. M = 0.600

Fig. 13 Centerline Mach Number Distributions for Various Diffuser Flap Positions at θ_w = 0 and ω = 0

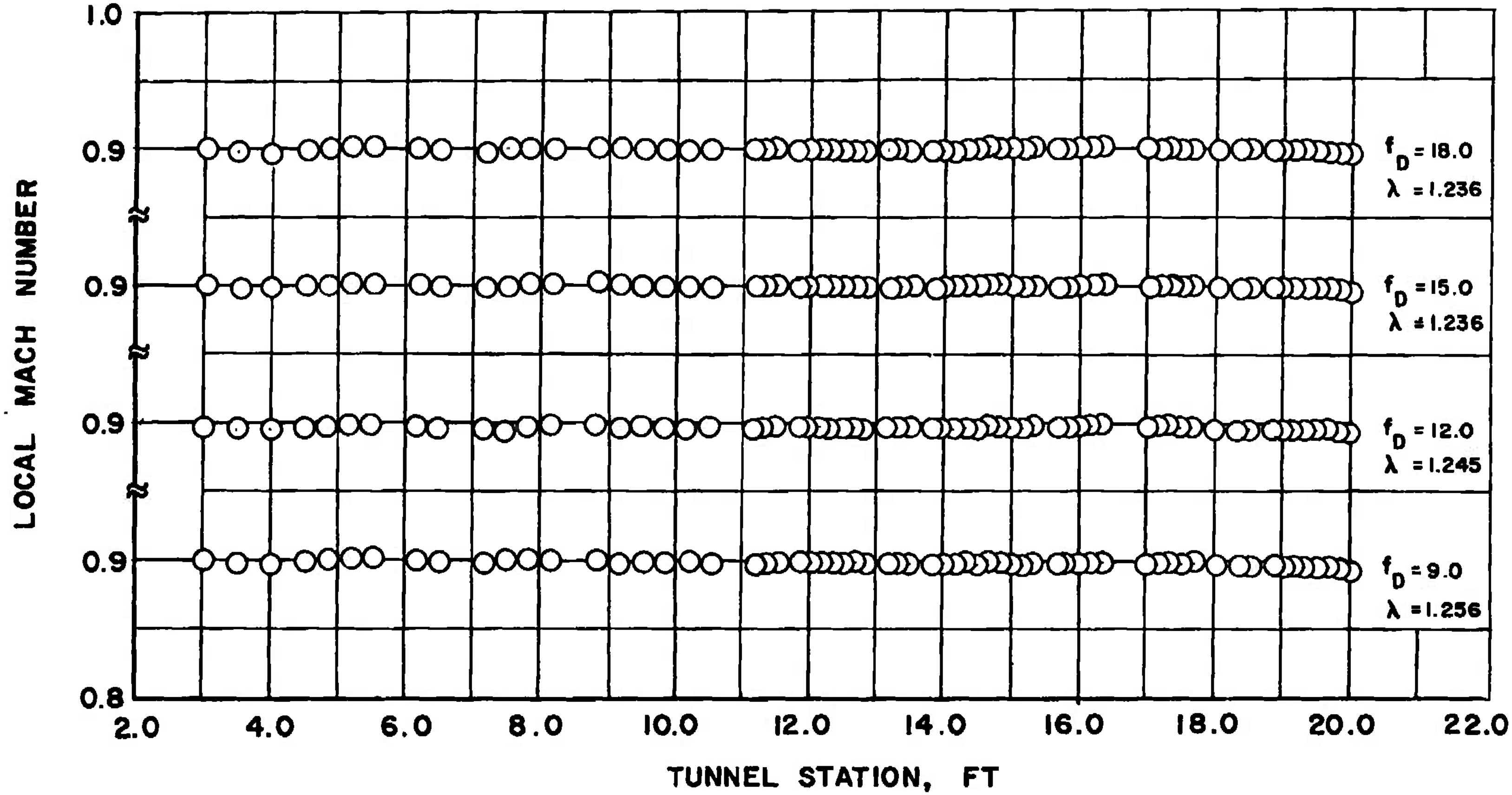


b. M = 0.702
Fig. 13 Continued

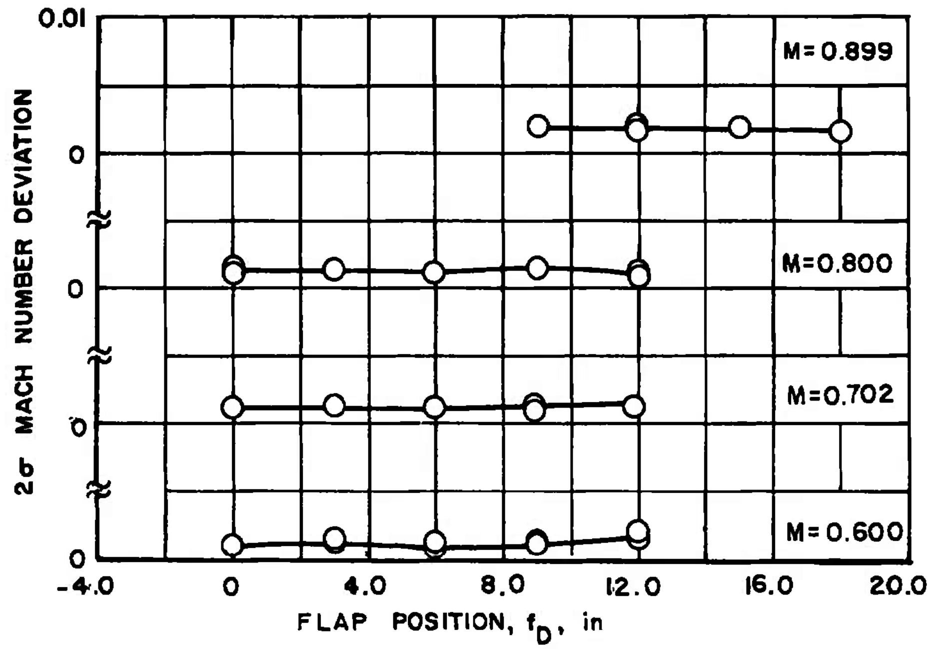


c. M = 0.800

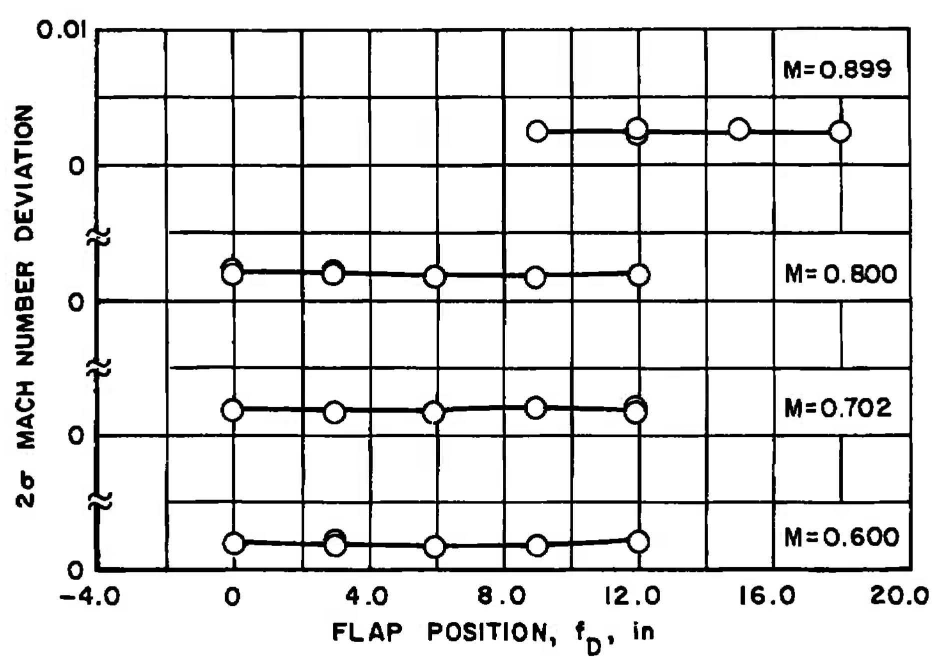
Fig. 13 Continued



d. M = 0.899
Fig. 13 Concluded

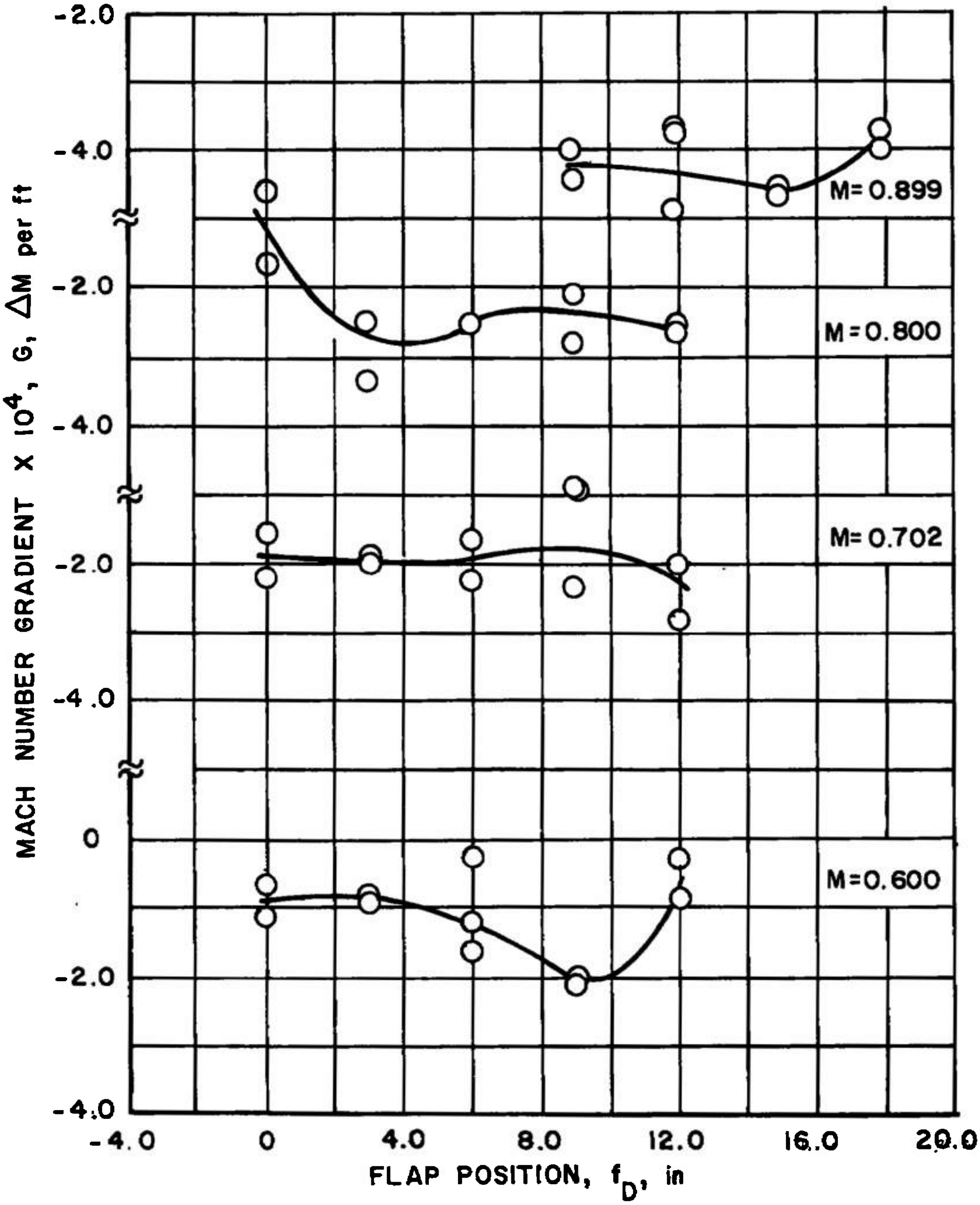


a. Tunnel Station 7.83 to 13.17



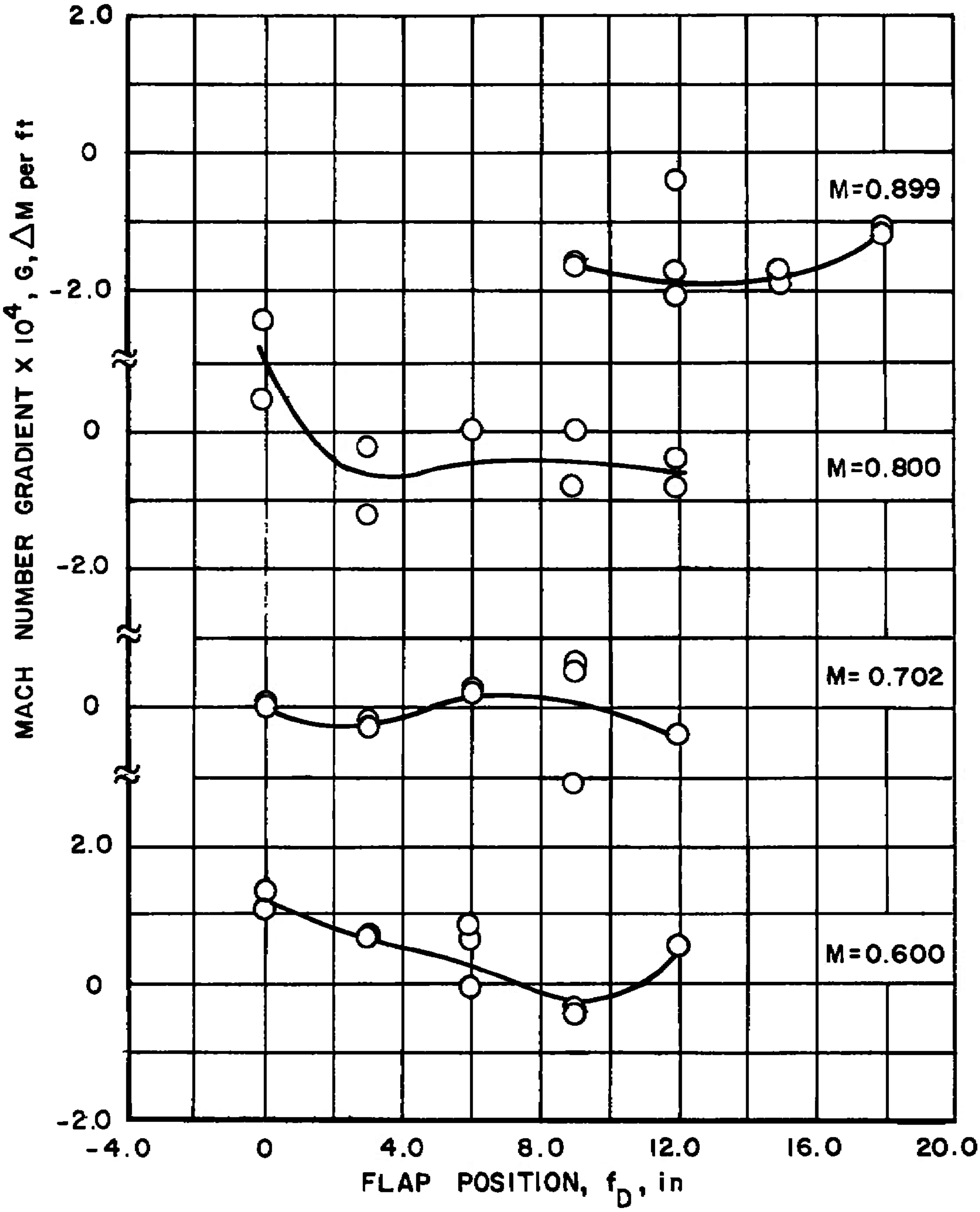
b. Tunnel Station 3.00 to 19.00

Fig. 14 Effect of Flap Position upon the Mach Number Deviations at $\theta_w = 0$ and $\omega = 0$



a. Tunnel Station 7.83 to 13.17

Fig. 15 Effect of Flap Position upon the Mach Number Gradients at $\theta_w = 0$ and $\omega = 0$



b. Tunnel Station 3.00 to 19.00
Fig. 15 Concluded

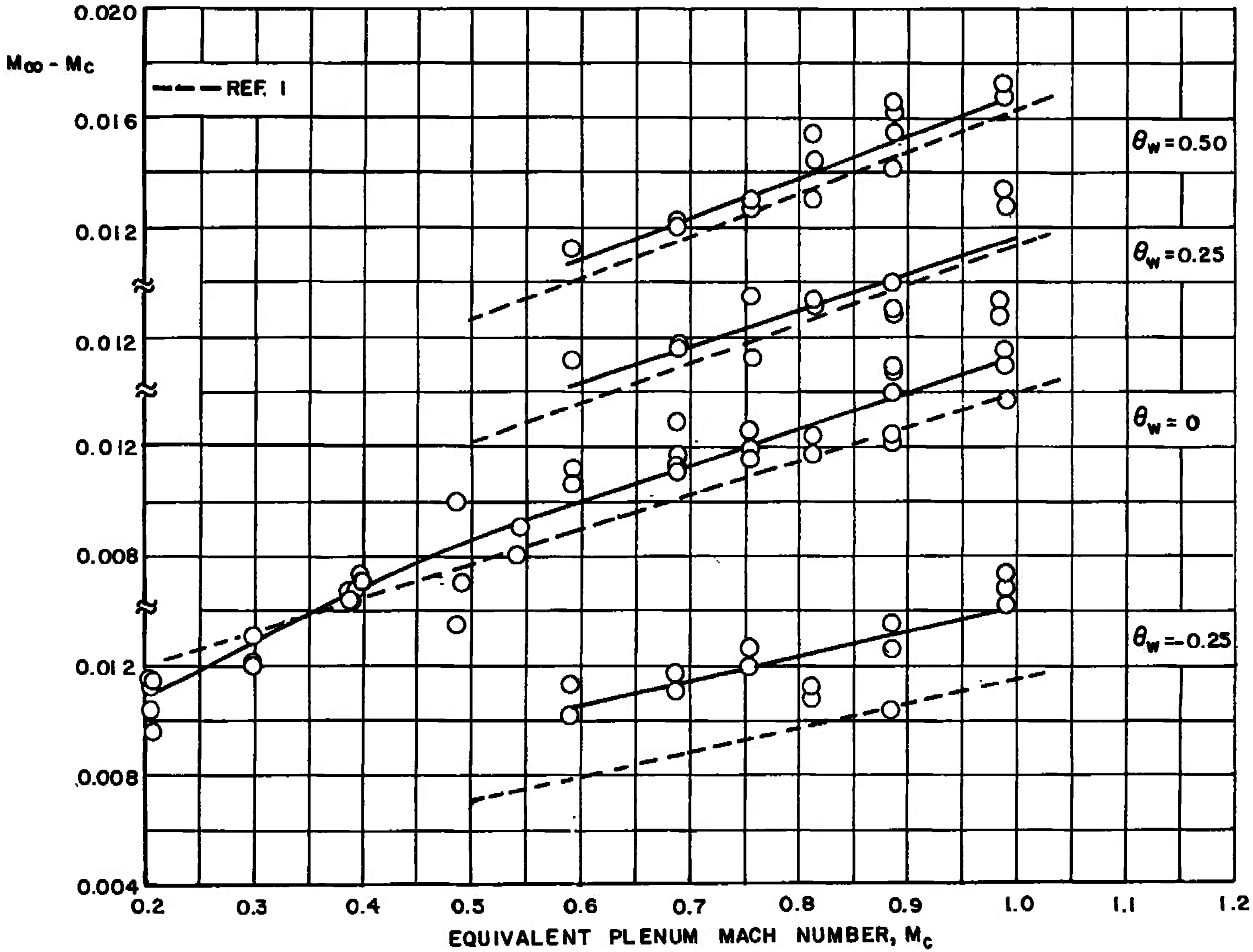


Fig. 16 Mach Number Calibration for $f_D = 0$ and $\lambda = \lambda^*$

APPENDIX II
BUOYANCY CORRECTION

A longitudinal static pressure gradient in a wind tunnel test section produces extraneous forces which are referred to as buoyancy forces. The buoyancy force is dependent upon a model area distribution as well as the tunnel static pressure distribution.

The distributions of Tunnel 16T static pressure (in coefficient form), as determined from the measurements with the centerline pipe, are illustrated in Fig. II-1 for $\theta_W = 0.25$, $\lambda = \lambda^*$, and for Mach numbers from 0.60 to 1.00. These data indicate that the static pressure and therefore the pressure gradient varies nonlinearly with tunnel station. For this case, according to Ref. 3, the buoyancy drag coefficient is equal to the enclosed area of a plot of local static pressure coefficient against model cross-section area divided by the coefficient reference area (A/S).

If a linear longitudinal static pressure gradient exists, Ref. 3 indicates that the buoyancy drag force is equal to the negative product of the pressure gradient ($dP/d\ell$) and the model volume. Utilizing the Mach number gradient, G, which is defined in Section 3.3, the buoyancy drag coefficient may be determined from the following equation:

$$\Delta C_D = G \, \eta \, \frac{V}{S} \qquad \text{(II-1)}$$

where G is the Mach number gradient ($dM/d\ell$), ΔM per ft; V is the model volume, ft^3; S is the coefficient reference area, ft^2; and

$$\eta = -\frac{dP}{d\ell} \cdot \frac{1}{G\, q_\infty} = -\frac{dP}{dM} \cdot \frac{1}{q_\infty} \qquad \text{(II-2)}$$

where q_∞ is the free-stream dynamic pressure.

Assuming one-dimensional isentropic flow, the right-hand side of Eq. (II-2) can be expressed as a function of free-stream Mach number, M_∞, and the ratio of specific heats, γ. This relationship and the variation of the buoyancy-Mach number parameter, η, for $\gamma = 1.4$ are shown in Fig. II-2.

The C-5A correlation test was selected to illustrate typical buoyancy corrections for tests in Tunnel 16T. The distribution of the C-5A model cross-section area divided by reference wing area is shown in Fig. II-3. The buoyancy drag coefficients were determined for $\theta_W = 0.25$ and a Mach

number range from 0.6 to 0.9 using two techniques. First, as indicated by Ref. 3 for a nonlinear pressure gradient, the buoyancy was determined by integrating cross plots of Figs. II-1 and II-3. Secondly, utilizing data presented in Figs. 12a, II-2, and the area under the curve presented in Fig. II-3 (which is the parameter V/S), the buoyancy was calculated using Eq. (II-1). A comparison of the results is presented in Fig. II-4. These results indicate that it is acceptable to assume a linear Mach number gradient and utilize Eq. (II-1) to compute the buoyancy corrections. To apply the buoyancy corrections to wind tunnel data the following equation is used:

$$C_{D_{corrected}} = C_{D_{measured}} - \Delta C_D \qquad \text{(II-3)}$$

To obtain accurate results using Eq. (II-1), the Mach number gradients must be defined for the test region in which a particular model is installed. The variations of the Tunnel 16T Mach number gradients with test region length for various test region locations, x, are presented in Fig. II-5 for $\theta_w = 0.25$, $\lambda = \lambda*$, and Mach numbers of 0.60, 0.70, 0.80, 0.90, and 1.00.

The data presented in Section IV indicate that the Mach number gradients can vary significantly with Mach number, tunnel pressure ratio, and test section wall angle. It is beyond the scope of this report to present the Mach number gradients for all possible combinations of tunnel parameters. For various operating conditions, the data presented in Fig. II-5 and Section IV can be utilized to determine an approximate value for the buoyancy drag. Such results can be utilized to evaluate the need for buoyancy corrections for tests at subsonic Mach numbers in Tunnel 16T.

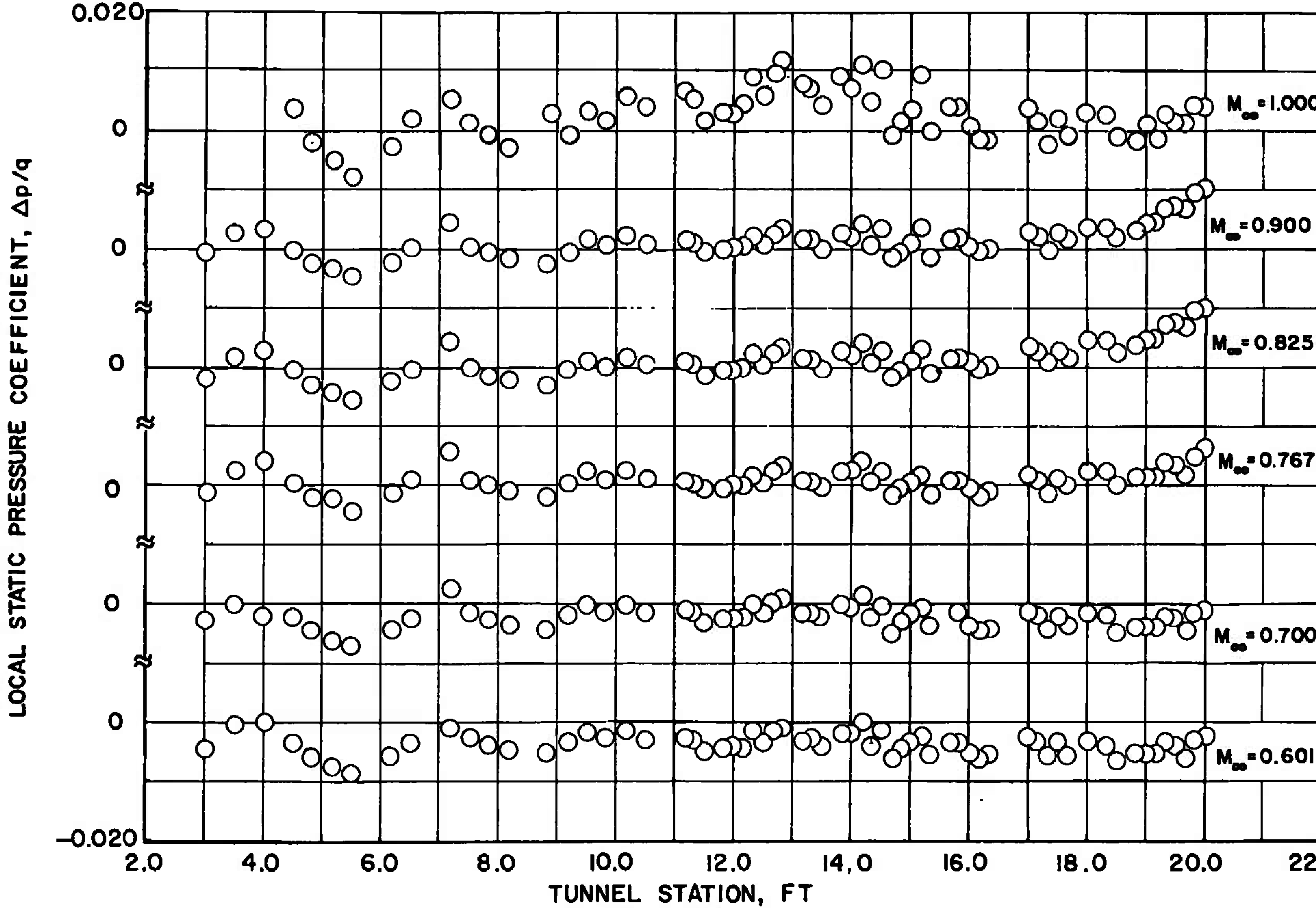


Fig. II-1 Tunnel 16T Centerline Static Pressure Distribution for θ_w = 0.25 and $\lambda = \lambda^*$

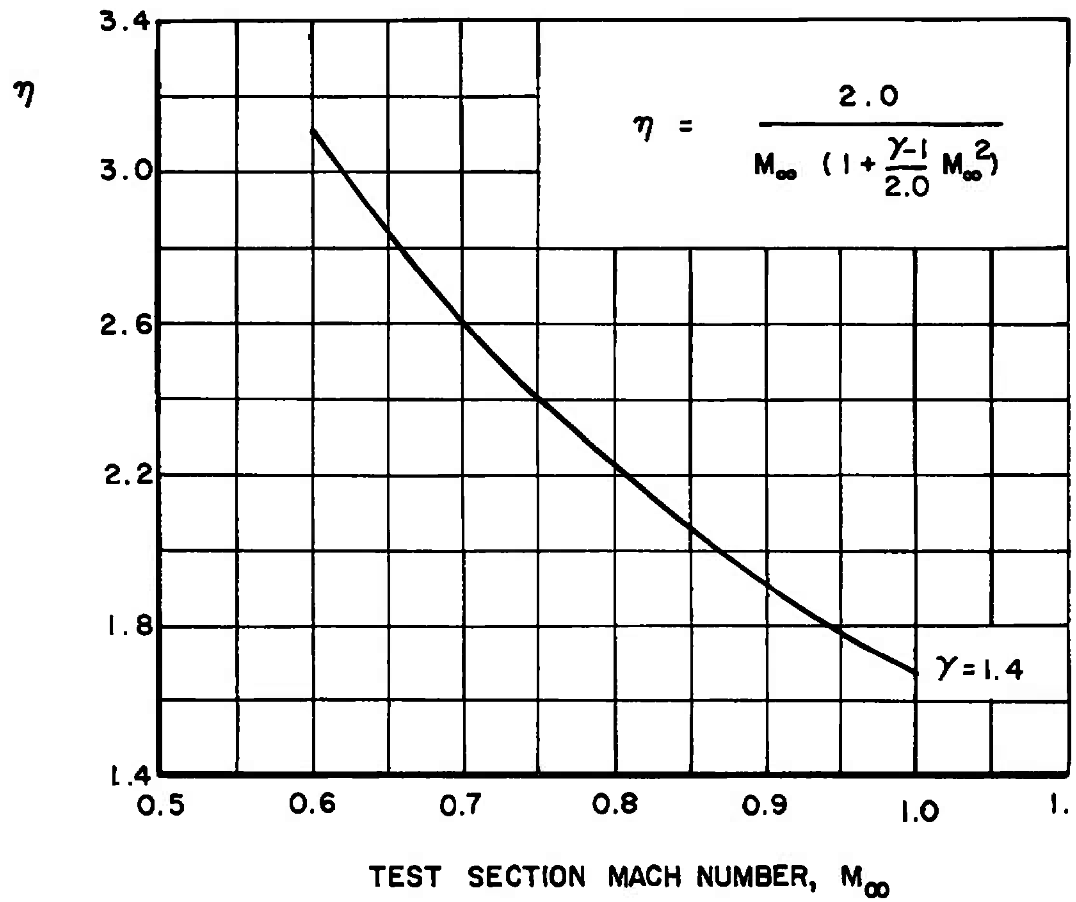


Fig. II-2 Variation of the Buoyancy-Mach Number Parameter for $\gamma = 1.4$

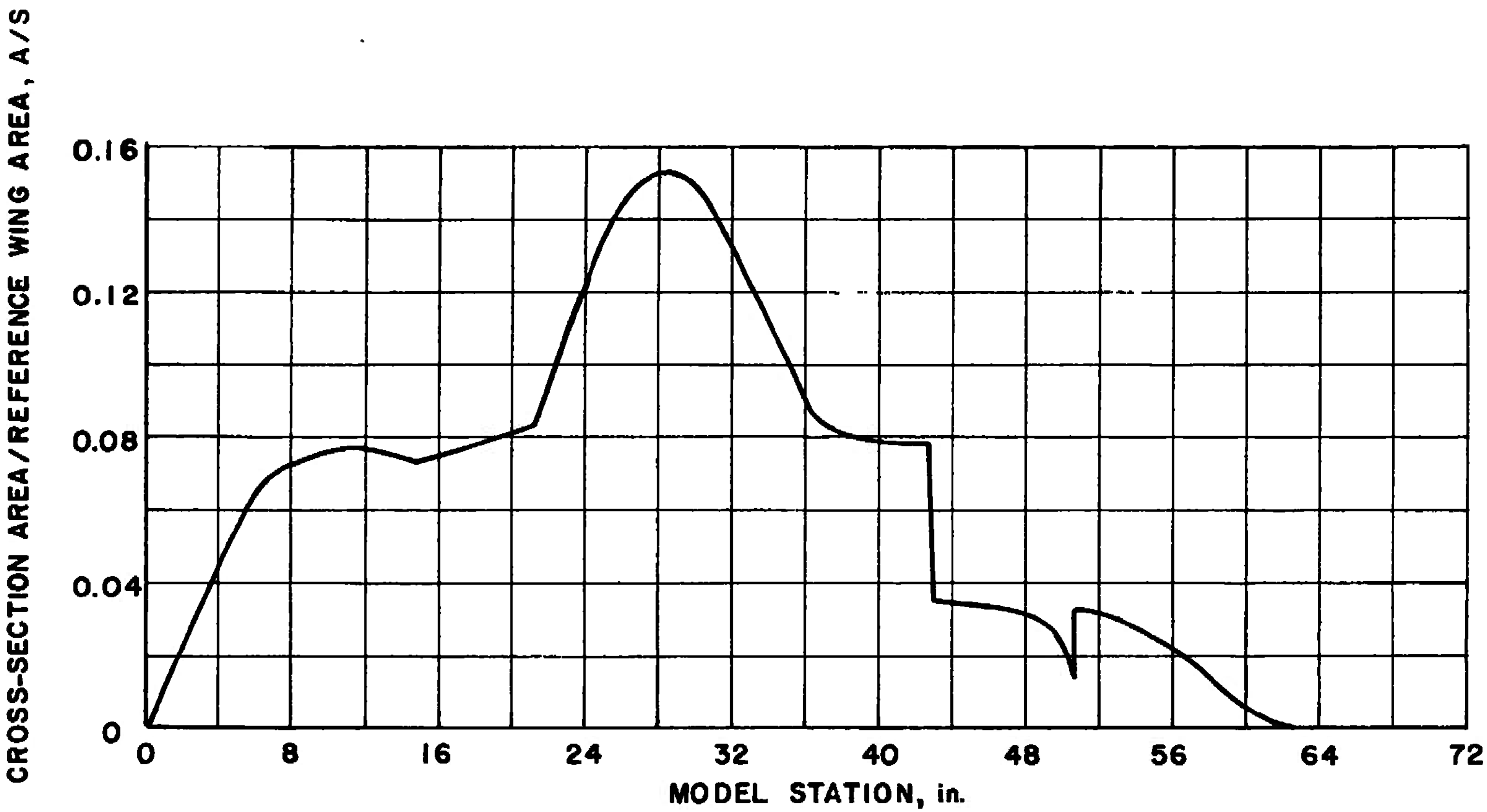


Fig. II-3 Area Distribution for the C-5A Correlation Test Model

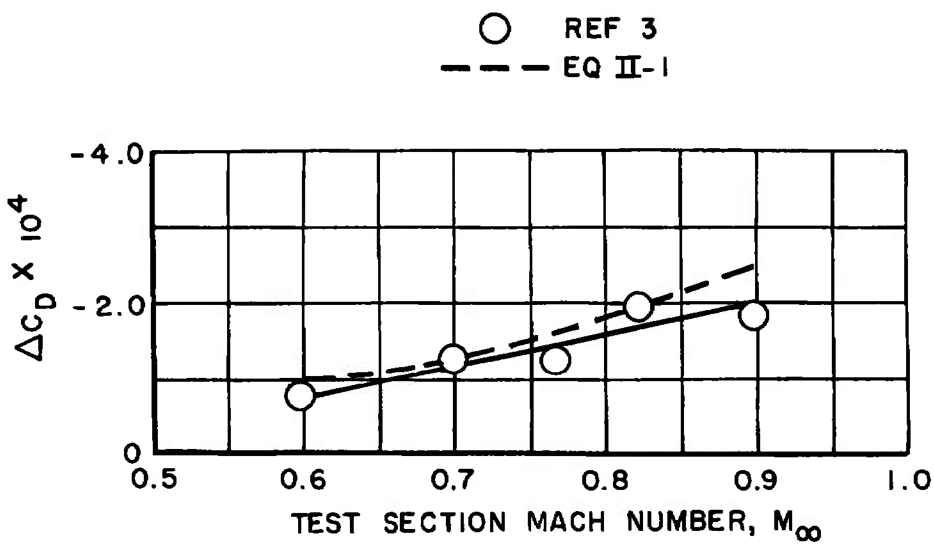
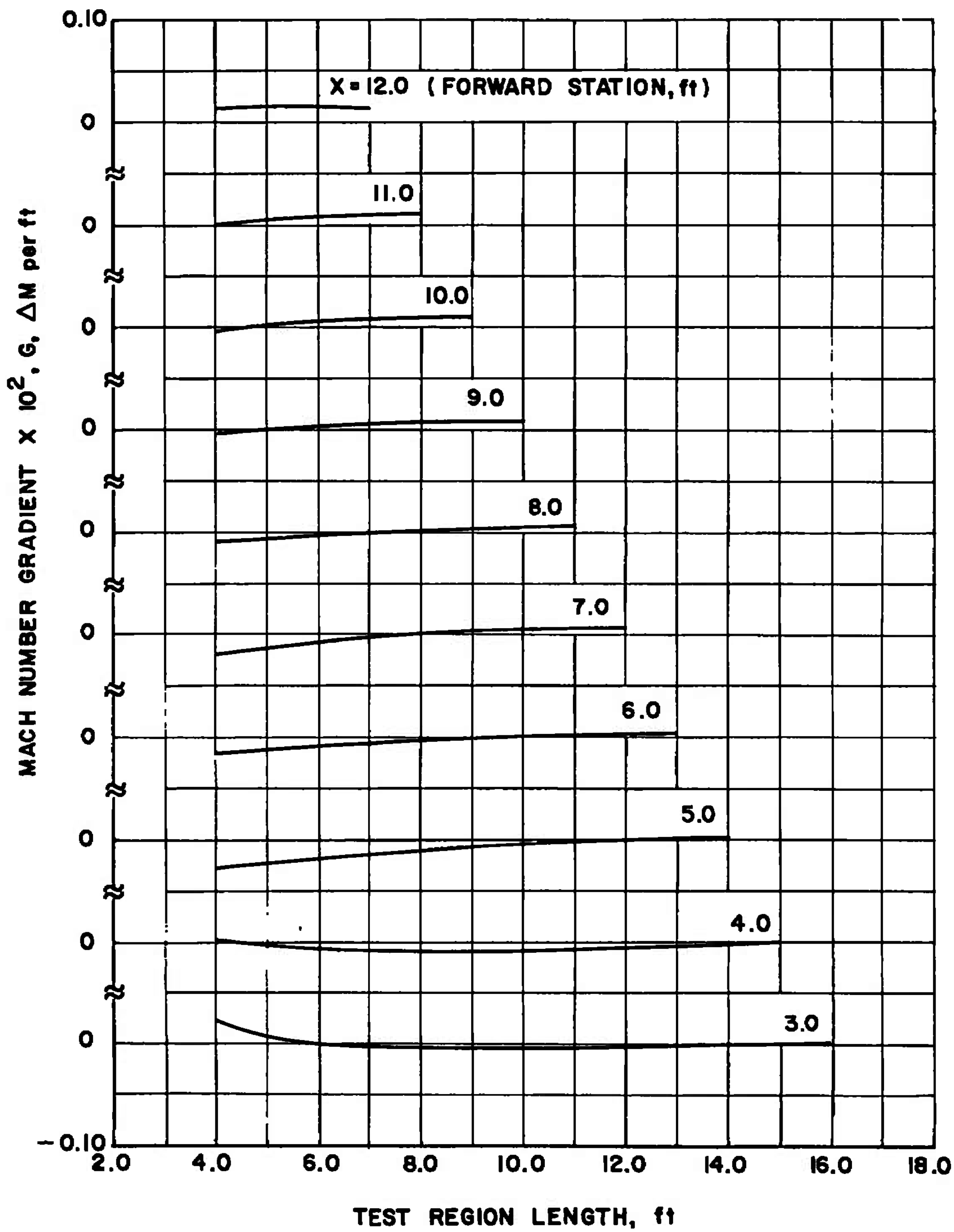
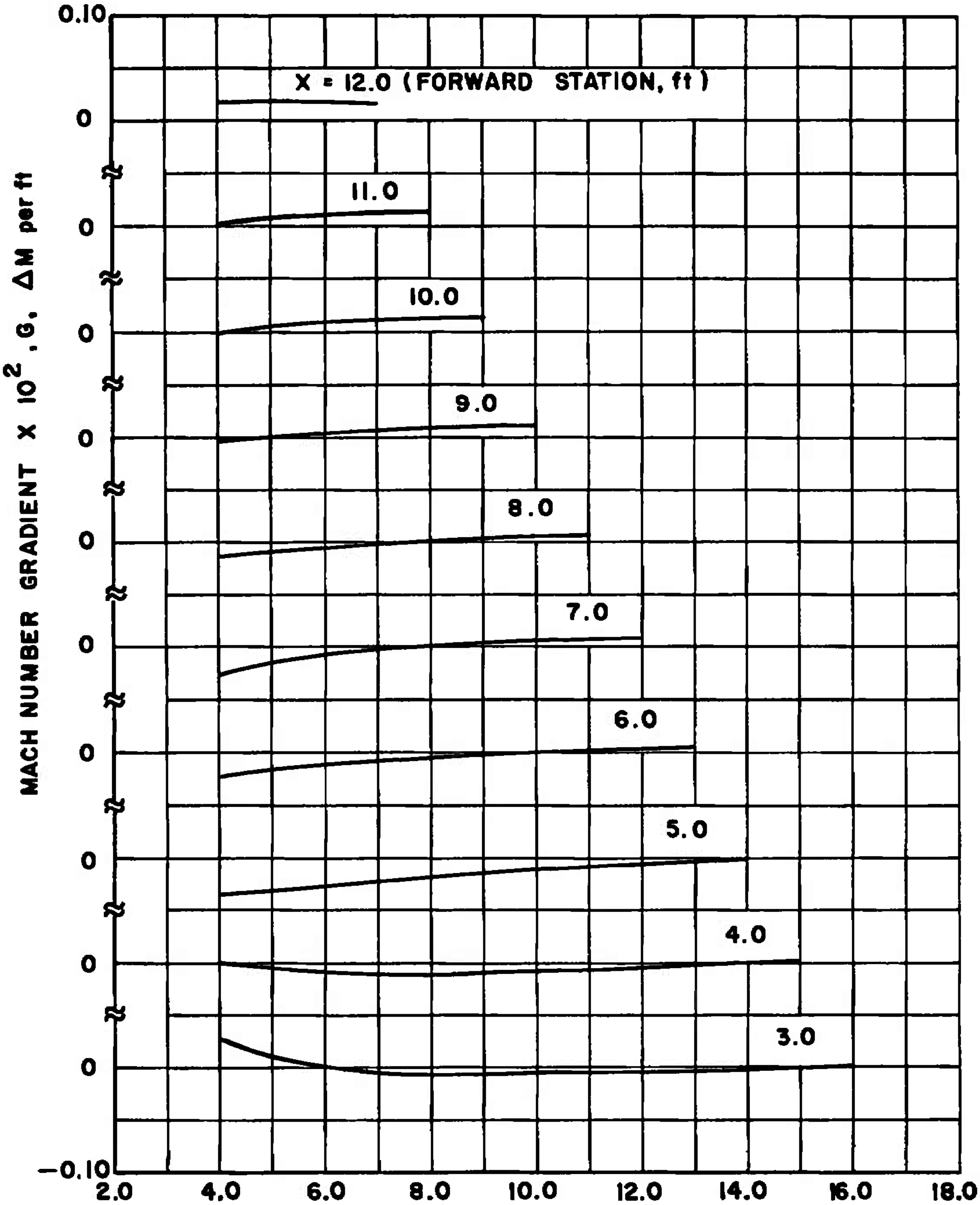


Fig. II-4 Buoyancy Correction for the C-5A Correlation Test at θ_w = 0.25

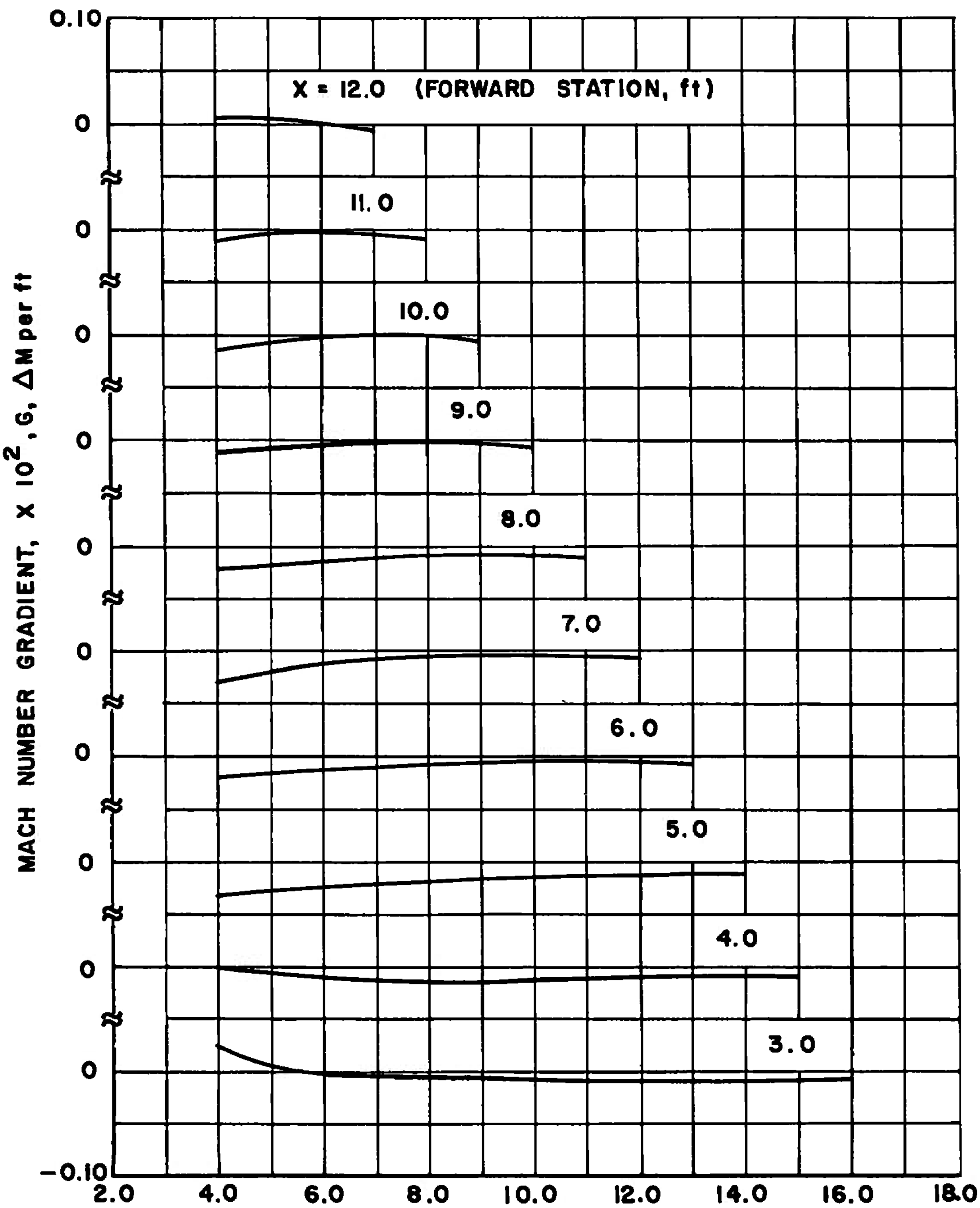


a. M = 0.60

Fig. II-5 Tunnel 16T Centerline Mach Number Gradients for θ_w = 0.25 and $\lambda = \lambda^*$

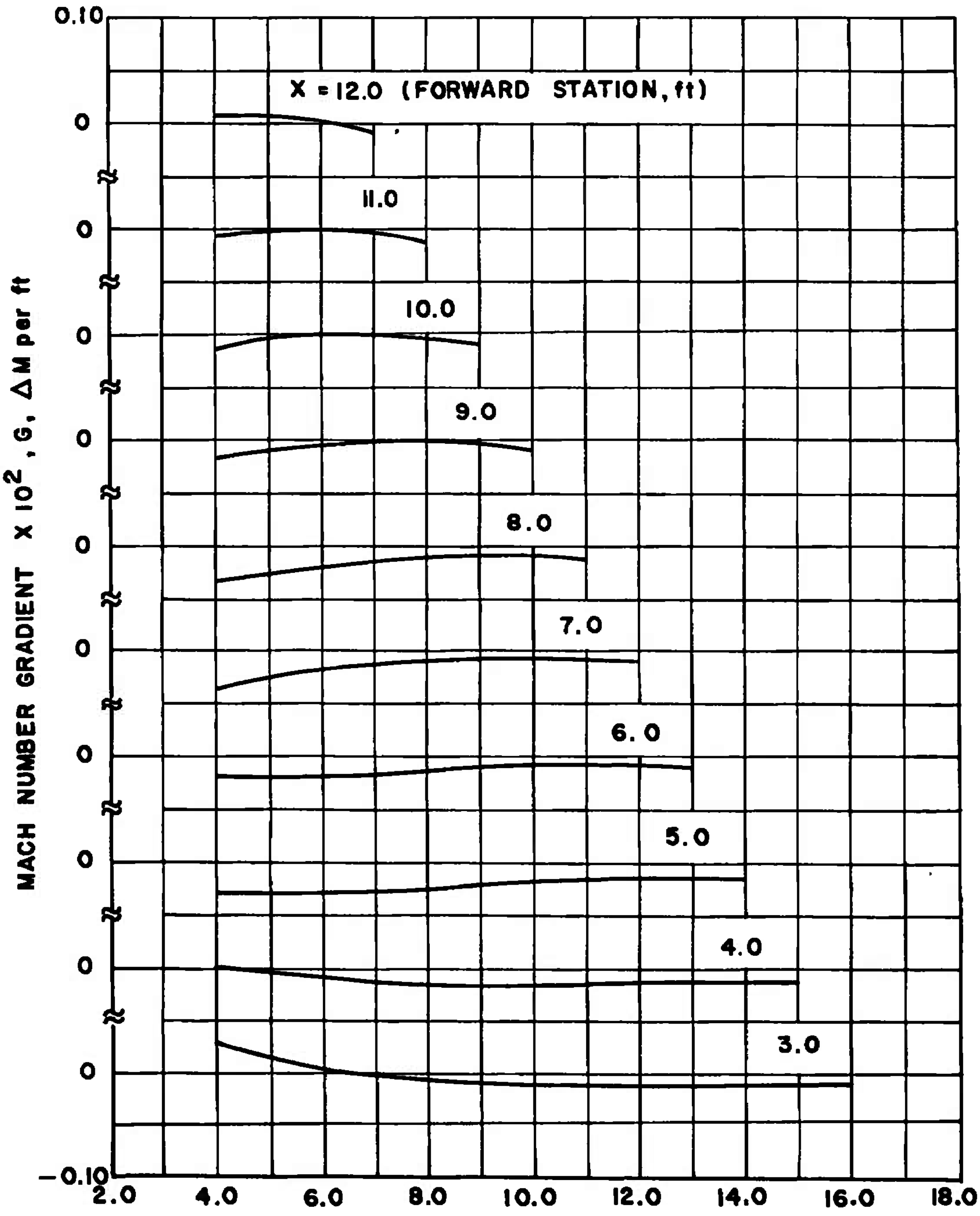


b. M = 0.70
Fig. II-5 Continued

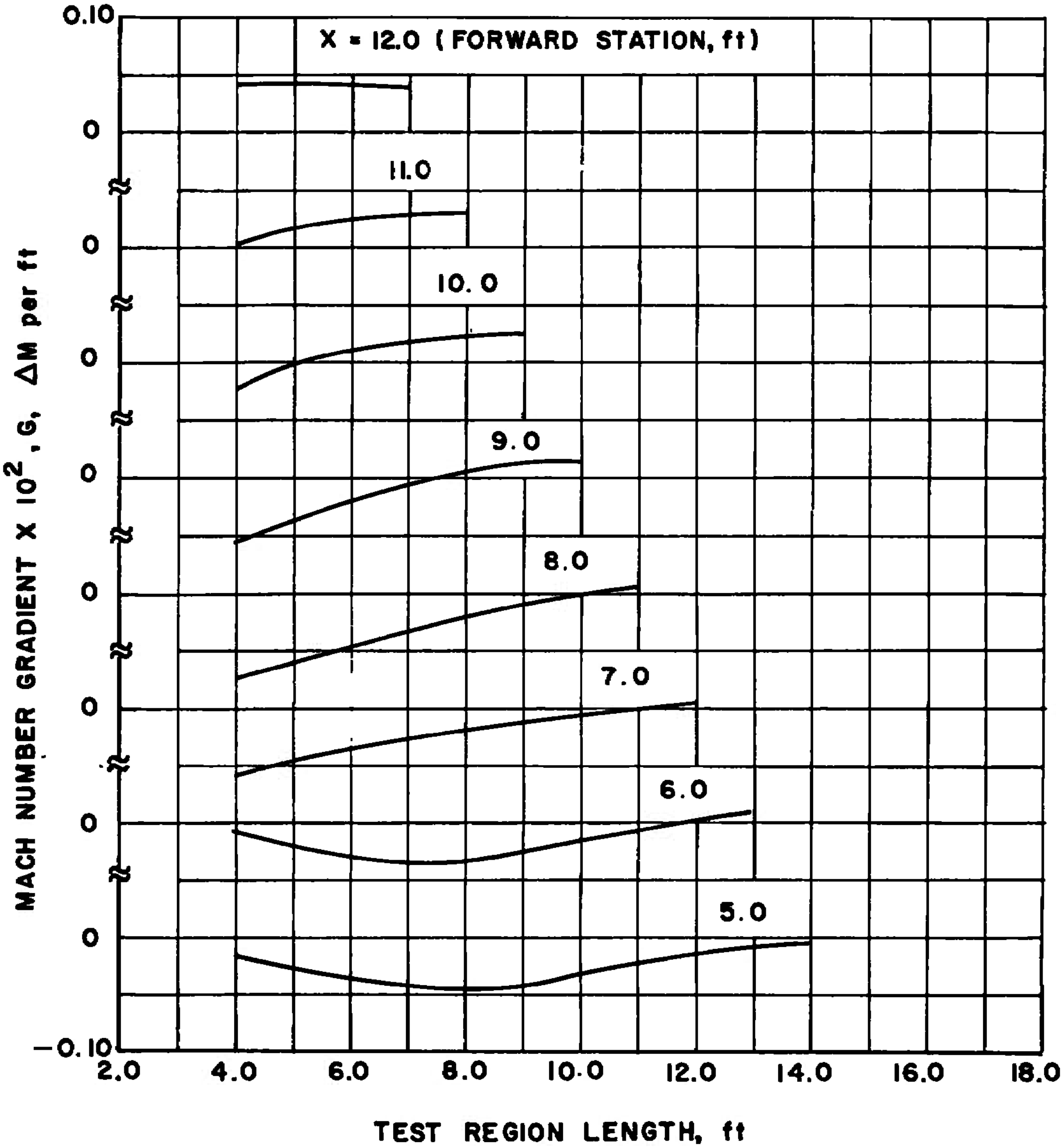


c. M = 0.80

Fig. II-5 Continued



d. M = 0.90
Fig. II-5 Continued



e. M = 1.00
Fig. II-5 Concluded

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)* Arnold Engineering Development Center ARO, Inc., Operating Contractor Arnold Air Force Station, Tennessee	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP N/A

3 REPORT TITLE

SUPPLEMENTAL CALIBRATION RESULTS FOR THE AEDC PROPULSION WIND TUNNEL (16T)

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
Final Report - December 30 and 31, 1969

5. AUTHOR(S) *(First name, middle initial, last name)*

F. M. Jackson, ARO, Inc.

This document has been approved for public release its distribution is unlimited. Per AF Letter dtd 19 April 75 Signed William Cole

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1970	62	3

8a. CONTRACT OR GRANT NO. F40600-71-C-0002	9a. ORIGINATOR'S REPORT NUMBER(S) AEDC-TR-70-163
b. PROJECT NO.	
c. Program Element 62201F	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)* N/A
d.	

10. DISTRIBUTION STATEMENT ~~This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of Arnold Engineering Development Center (AETS), Arnold Air Force Station, Tennessee 37389.~~

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Available in DDC	Aeronautical Systems Division ~~(ASNFD-20), Wright-Patterson~~ Air Force Base, Ohio 45433

13. ABSTRACT

Tests were conducted in the AEDC Propulsion Wind Tunnel (16T) to determine the centerline Mach number distributions and the corresponding tunnel calibration parameters. The tests were conducted over the Mach number range from 0.20 to 1.00. A quantitative evaluation of the effects of Mach number, tunnel pressure ratio, test section wall angle, and diffuser flap position upon the centerline Mach number distributions was determined by analysis of the local Mach number deviations and the longitudinal Mach number gradients. The results indicate that the centerline Mach number distributions are better than the wall distributions obtained during a previous calibration. For most operating conditions, the difference between the present centerline calibration and the previous calibration is considered negligible.

DD FORM 1 NOV 65 1473

UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
1 transonic wind tunnels -- Calibration						
2 " calibrating " " -- PWT						
3 Mach numbers distribution						

AFSC Arnold AFS Tenn